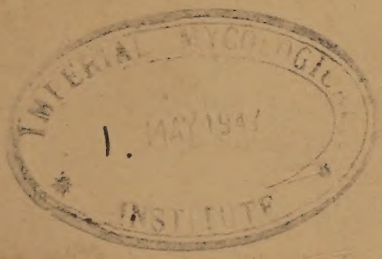
FORESTRY

THE JOURNAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

Edited by C. W. SCOTT

VOLUME XX

1946



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SOCIETY OF FORESTERS OF GREAT BRITAIN

THIS SOCIETY was formed in 1925 and adopted its first Constitution at Oxford in 1926. The object of the Society is to advance and spread in Great Britain the knowledge of technical forestry in all its aspects.

The Society consists of Professional and Ordinary Members. Professional membership is divided into two orders:

FELLOWS, being holders of a degree or diploma in forestry, and subjects of the British Crown, but not necessarily resident in Great Britain; and

ASSOCIATES, being subjects of the British Crown resident in Great Britain, whole-time foresters, and not eligible for Fellowship. They pay a less subscription than Fellows but have almost equal privileges.

Ordinary membership is open to persons not eligible for either of the above.

Office-bearers and Councillors are nominated by Professional Members, and in the event of competition for any office a postal ballot of the whole Professional membership is held. The following were elected to serve in 1946:

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THE SOCIETY AND ITS JOURNAL

THE IMPORTANCE OF FORESTRY is being realized more and more in Great Britain. The number of foresters is increasing steadily, and a forestry profession is gradually being built up. It is intended that this Society should be representative of the profession. Those who are not engaged in the practice of forestry or the allied sciences are cordially invited to join the Society as Ordinary Members.

SUBSCRIPTIONS are:

Fellows and Ordinary Members: £1. 1*s*. 0*d*. annually or £10. 10*s*. 0*d*. for Life.

Associates: 10*s*. 6*d*. annually.

THE SOCIETY'S JOURNAL, called *Forestry*, is usually published twice a year, in June and December. It provides a means for the publication of the results of practice and research both in the growing of timber and in its utilization, including such basic sciences as forest physiology and ecology, forest soils, wood structure, and timber physics, and allied sciences such as forest entomology and forest mycology.

CONTRIBUTIONS may be accepted from members and others resident either in Great Britain or abroad. They should be sent to the editor, C. W. Scott, 'Downhill', Ellesborough Road, Wendover, Aylesbury, Bucks. No article should be submitted which is being offered to any other journal for prior or simultaneous publication. Articles should be typewritten, and must be in a final form suitable for publication. References to literature should be collected at the end of the paper, and arranged alphabetically according to author's name, and numbered. In the text each reference should be indicated by its number enclosed in brackets. Each article should conclude with a summary. It should give the methods, extent of material, observations, and results, but should be brief and not exceed 3 per cent. of the original. It is understood that the author waives any copyright or translation rights in such summaries and that their reproduction in other publications will be permitted, subject to the source being duly acknowledged. Twenty reprints of the article will be sent free to each contributor and a reasonable number may be purchased by the contributor if ordered when the proofs are returned. The Society as a body takes no responsibility for the views expressed by contributors.

Forestry is sent free to members of the Society; others may register as subscribers by application to the Secretary, R. Angus Galloway, 8 Rutland Square, Edinburgh, 1.

SOCIETY'S MEDAL. For the rules concerning the award of this Medal see vol. XX, pp. 80–1.

PROFESSOR H. M. STEVEN

Editor of FORESTRY, 1926–46

AN APPRECIATION

WHEN the Society of Foresters was started in 1925 one of its first acts was a decision to produce a technical journal which would cover the theory and practice of forestry in Great Britain. Such a journal, if it was to meet the professional needs of the Society, had to set and maintain a high standard for its articles, to keep abreast of current developments in scientific knowledge as well as in technique, and to hold a judicious balance as regards the space allotted to different branches of the profession. The man selected for the responsible and exacting post of editor of the new Journal was a young Scotsman, Dr. H. M. Steven, then a Research Officer of the Forestry Commission and later Professor of Forestry in the University of Aberdeen. For twenty years Steven has faithfully served the Society in his editorial capacity.

Steven's position as Research Officer gave him many useful contacts in academic circles as well as among all ranks of professional foresters in this country. The success with which he used these contacts is enshrined in the thirty-one numbers of *Forestry* which have been issued during his editorship. The first few numbers of the Journal were generally acclaimed. Some wiseacres shook their heads and doubted if the standard set could be lived up to, but that standard has been maintained, an achievement requiring quite exceptional tact and perseverance on the part of the editor.

Among his other qualities Steven showed remarkable skill in the balance he maintained in the Journal between various aspects of forestry. He secured outstanding contributions, such as those of the late Professor Priestley, to the scientific bases of forestry, and also a steady succession of noteworthy articles on general forestry problems and methods, and on the more specialized but vital subjects of forest products research. Steven was also very successful in stimulating the younger men in the profession to write, and he was tireless in his search for fresh talent. On what we may term the 'blue pencil' side of the editorial job, Steven showed a rare combination of tact, helpful suggestion, and firmness which disarmed even the most recalcitrant of his contributors and encouraged future output.

Largely as a result of Steven's brilliant conduct of the Journal, *Forestry* has gained an international reputation in the forestry services of the world. The large and steadily increasing demand from abroad for current and past numbers is ample evidence for this statement.

In conclusion, no appraisal of Steven's services to *Forestry* would be complete without acknowledging the special debt of gratitude which the Society owes him for continuing to produce the Journal under the unparalleled strain of the war years. Like most of us he was doing several whole-time jobs, and the added effort of carrying on the Journal, even on a one volume per annum basis, must have been very substantial.

Now after twenty years of outstanding service Professor Steven vacates the editorial chair, but he will continue to take part in all the activities of the Society.

His successor as editor is Mr. C. W. Scott, formerly in the Burma Forest Service and now on the staff of the Forest Products Research Laboratory at Princes Risborough.

Let us give the Journal all the support and encouragement we can so that it may carry on the tradition and maintain the standard so ably set by the first editor.

W. H. GUILLEBAUD

A PROBLEM OF FOREST FINANCE

By W. L. TAYLOR, C.B.E.

IT has hitherto been a generally accepted convention in the economics of systematic forestry for all expenditure of a *capital* nature to bear the burden of compound interest. On the data it is customary to advance financial purists would scarcely have it otherwise; furthermore, academic approach to fundamental problems of forest valuation has made subservience to the compound interest tables almost inevitable, more especially as researches into the mathematical implications of forestry practice had their origin in countries where a wealth of natural forest still existed, or forests had been the subjects of long-standing conservation. Thus, at the outset, the major element of forest capital, the stands of growing trees, were received in those countries as a free gift from the bounty of nature or as a legacy from forest-loving forebears, and, in the circumstances, it is not so surprising that the imposition of cumulative charges on subsequently expended capital by computing interest at compound rates could be supported with a certain complacency. Forestry has thus inherited a basis of financial accounting which, prima facie, seems to have satisfied all schools of thought, but it may be well to attempt to examine how far these accepted ideas are wholly applicable to the artificial establishment of forests.

Whatever some foresters may have been thinking, the bogy of compound interest has not yet been effectively challenged in the theory of forest finance. The long delay in the adoption of a National Forest Policy in Great Britain is traceable, in part, to uncertainty about the answer to the query 'Does forestry pay?'; private forestry has certainly been, and still is, daunted by this perennially posed question.

The problem can be approached from two directions:

(*a*) In what circumstances do the compound interest tables rightly apply to creative enterprise?

(*b*) What are the true values arising from forest policy:

(1) to the State;

(2) to the private owner of woodland?

Generally speaking, interest at compound rates is the rule in long-term transactions in which the reward of capital is deferred and is incapable of being touched upon until after the lapse of years. In so far as the actual operations of planting, tending, and harvesting a forest crop are concerned, the circumstances may, at first glance, appear to conform to this general thesis. When, however, we analyse the benefit to be derived from the practice of forestry, and in particular to forestry in an island kingdom such as Great Britain, it becomes clear that there are important, if intangible, considerations beyond the expected proceeds of an ultimate sale of the timber trees. These may be grouped broadly under the headings of security, employment, compulsory saving, and amenity, together with the

relatively minor values arising from shelter, soil protection, and water conservation. It is because of the national importance of these things, a grave importance in regard to security, and because forestry is a long-term investment in all its aspects, that it has become recognized, almost throughout the world, that national forest policy involves considerations which can only properly be controlled by the State.

What then is the governmental view of public spending for the national good, and how are forestry values, tangible and intangible, to be reduced to terms to which the customary business principles governing principal and interest can apply? Is it also possible so to reduce all implications of forest policy to present values? Surely the answer must firstly be sought by reference to current principles of public spending and secondly in the fact that to the cash value of the forest crop when mature there must always be added *X*, the unassessable (in terms of present values).

Money in large sums is spent on education and other national services in faith that, like bread cast upon the waters, the benefit, or the interest on capital, will return after many days, although the precise value of this return is certainly not fully calculable by actuarial methods; in many instances the spending recurs periodically because men and material (i.e. capital) wear out and must be replaced. The careful calculations which went to show that, in the conditions obtaining prior to 1939, large-scale forestry would give a return of 3 to $3\frac{1}{2}$ per cent. on outlay took no account, arithmetically, of the intangibles. Even the purely material computation of cost and deferred revenue in this way is on an uncertain basis because no one is able to foretell the prices standing timber will command 70 to 150 years ahead or to translate these unknown future prices into money values of the present time. Neither can the course of wages be predicted.

For one reason or another our railways are said to-day to be over-capitalized, that is, on the basis of cash revenue they fail to pay *simple* interest on all capital cost. Imagination staggers at the picture of current railway accounts if the capital sunk in the past 100 years were all chargeable at *compound* interest rates. The thing is unthinkable. All the same we cannot do without our railway communications and also maintain national security and our standard of living. By comparison it seems that by recourse to the cramping 'safeguard' of compound interest, forest accounting seeks to have it all ways. Forests must be conserved or planted if the supply of forest products, also essential to our standard of living, is to be maintained, just as wheat must be sown if the world is not to starve. But the railway undertakers could not know, and the forester and farmer cannot be certain of, the precise result of their enterprise in terms of interest on total capital outlay; any attempt to express such results in terms of present values must prove fallacious in the great majority of human undertakings.

The periodic fluctuation of Consols, for a long time the most gilded of gilt-edged securities, is illuminating. It will be seen that even on a long-term investment of this sort it is impossible to be certain that capital will be realizable

intact at any given date, or to guarantee preservation of the original rate of interest:

	Highest	*Lowest*
1820, interest 3%	70½	65⅜
1850, „ „	98⅜	94⅜
1900, interest 2¾% from 1889	103¼	96¾
1910, „ 2½% from 1903	83¼	78⅜
1920, „ „ „ „	52	43⅝
1930, „ „ „ „	59¼	52¾
1940, „ „ „ „	77	68⅛
1946, „ „ „ „	over 91½	91 3/16

The fact is that all investment involves an element of speculation however meticulously future risks may be discounted. Banks and insurance companies may fail, business enterprise may come to nought, and capital may fail to reproduce itself, but unless previously accumulated capital is put to employment more or less speculatively there can be no human progress and no further accumulations of wealth. And yet speculation, however discreet, is the antithesis of all for which compound interest stands. Many thousands of millions of pounds have been expended on the building of the British Empire, much of which has long since ceased to yield interest payments in the form of money and has vanished as realizable capital. Nevertheless if this expended capital had never been adventured our Empire would to-day wear a very different aspect both to the individual and in world affairs. The truth is that, in spite of the teachings of political economy, capital continues almost universally to be thought of in terms of money, whereas money is only the token by which capital is popularly expressed. Thus confusion as to the true nature of capital and too narrow a conception of the deferred 'profit' of forestry continue to overshadow the forester's labours. Wisely invested capital at once becomes transmuted into other forms of wealth, the values of which tend further to change during the course of an undertaking, whether the term be short or long.

It is conceded that the nation must have forests. The puzzle is why forestry should be classed among the very few fields of public or private enterprise which are cumbered with compound interest when practically all analogous undertakings are free from its trammels; the promise of a faithfully worked-out National Forest Policy is as good as any, and better than most, because forests when brought to the point of sustained yield will, with proper management, continue indefinitely to support themselves and to yield beneficial results, the value of which cannot exactly be ascertained at the outset by any mathematical formula it is possible to apply.

Expenditure incurred by private foresters in planting or replanting woods is subject to the same general considerations as those which bear on State forestry, but there are differences in degree and the relevance of the arguments. An individual owner plants for cash profit; for amenity including covert and shelter; in lieu of an insurance policy; from a sense of duty to his heirs or the nation; or for any or all of these considerations. His enterprise has a national value that has become recognized by the governments of a number of countries, including that of Great

Britain, and is rewarded by money grants, loans, and other services. But the amounts of forestry grants from public funds are not determined by reference to compound interest tables nor is the interest on loans so calculated: money is given, or lent on easy terms, as a contribution in return for the service rendered to the timber resources of the nation, and as such is acknowledged to be a good 'investment' on behalf of the people. What rate of interest will actually accrue to the undertaking is left to the hazard of the future as by the nature of the case it must be.

If the private planter leans to financial purism, then he should examine his problem from all the angles of approach and evaluate not only the expected crop but all other benefits the growth of the crop will afford to his estate.

Thus the forester, State or private, performs a function the advantages of which reach out beyond the establishment of forests for the cash value of his crops. The worth to national and private forestry of these additional services is no less real because it is deferred and in part untouchable in terms of ready money. Financial calculations based on capital cost reckoned at compound interest for the period of the expected silvicultural rotation, set only against estimated cash returns deferred on the same principle, do not reveal more than a part of the full story.

Worship at the shrine of compound interest can, it seems, be carried too far.

ON THE EFFECT OF CHANGES IN ELEVATION, ASPECT, SLOPE, AND DEPTH OF FREE-ROOTING MATERIAL ON THE GROWTH OF EUROPEAN LARCH, JAPANESE LARCH, SITKA SPRUCE, AND SCOTS PINE IN MYNYDD DDU FOREST

By W. R. DAY

(*Department of Forestry, University of Oxford*)

IT may be shown by the analysis of suitably collected data that where the rooting profile of trees encounters some restricting layer in the subsoil, such as clay or hard rock, so that the major part of the root development necessarily takes place above this layer, there is a significant correlation between depth of free-rooting material within the soil profile and the height quality of the forest crop (i.e. total height at an age of 50 years). This was demonstrated for European larch by Mr. C. G. T. Morison, Reader in Soil Science, Oxford University, in an unpublished report dealing with data collected in 1940 and 1941 by the University Forestry Research parties in woods then being felled for war purposes. The data used referred to a heterogeneous collection of samples which were united mainly by the fact that the soil profile contained a fundamental layer which offered resistance to root development. They referred, thus, to soils which were shallow or only moderately deep in character, as a rule, but which might have very varying drainage characteristics, occupy very different topographical positions, and vary greatly in texture and base status. Because of this multiplicity of factors acting upon growth, the correlation with depth of free-rooting material was not high, the correlation coefficient being $+0{\cdot}32$ (Std. Error, $\pm 0{\cdot}10$). It was possible to demonstrate a more significant effect than this by isolating a particular class of soils. An example of this is shown in Fig. 1, which is derived from data referring to Scots pine which grew on loamy soils having few or no stones and an impermeable clay subsoil. A straight-line regression has been calculated for this, but the true regression is certainly curvilinear. The correlation coefficient has the value of $+ 0{\cdot}77$ (Std. Error, $\pm 0{\cdot}16$) and is significant although the number of observations is small. The higher degree of correlation exhibited in this case undoubtedly results from the more unified conditions under which the observations were made.

In the summer of 1942 observations were made jointly with the Reader in Soil Science, in European larch plantations in Mynydd Ddu Forest on the borders of Monmouthshire and Herefordshire, in order to investigate the possibility that height growth might again show a significant correlation with depth of free-rooting material. The data collected showed that while the expected correlation could be demonstrated for some restricted localities the observations as a whole failed to reveal any appreciable association between the chosen soil characteristic and height growth, although the soil was of a fundamentally similar character

throughout the area sampled. This suggested that other factors than the one observed were having a significant effect upon height growth and that a more detailed analysis involving more numerous observations would be required before progress could be made. The soil survey of this forest carried out in 1943 by Mr.

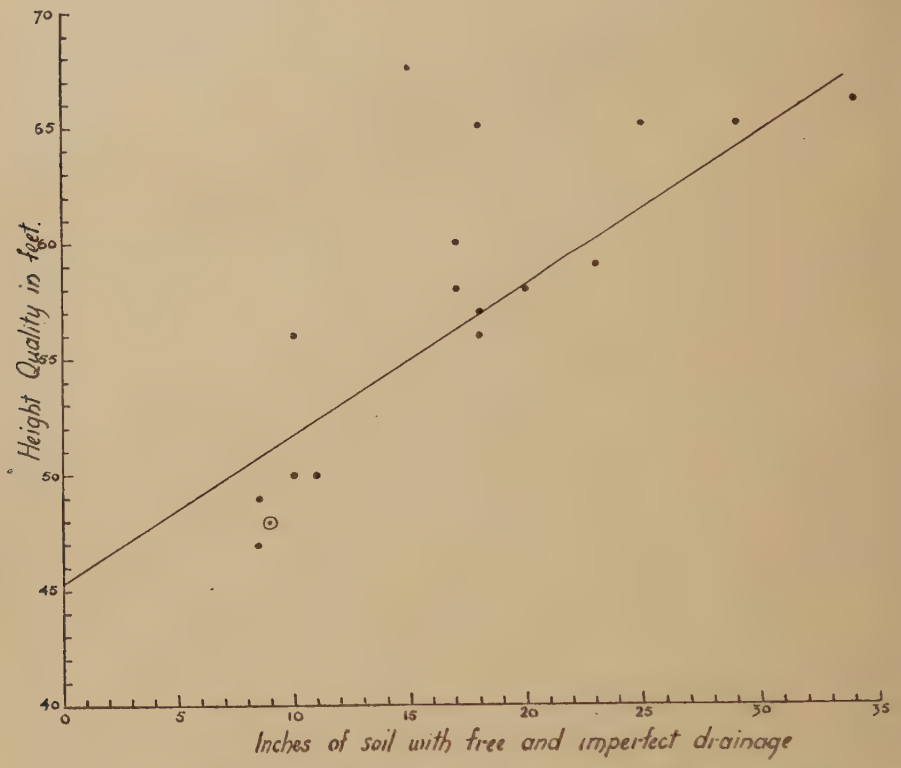


FIG. 1. Scots pine. On high and low base status brown earth soils (clayey subsoils), with impeded drainage, and few or no stones.

Morison and Miss Ackroyd gave the required opportunity for the collection of this information. Data capable of analysis were then obtained for the four principal species in the central and older part of the forest. These species are European larch, Japanese larch, Sitka spruce, and Scots pine. A summary statement of the data referring to these species is given in Tables I, II, and III. The soils referred to in Table II are mostly freely draining sandy loams derived from Old Red Sandstone rock. The gleyed podsol is an exception to this in that it exhibits impeded drainage and this and not the unweathered rock provides the root-restricting characteristic: this is the most infertile type of soil. All the soils are acid, having a pH lying between 4·0 and 5·0.

The data relating to mean height and soil depth were collected by taking samples at 50-foot intervals along the lines used by Morison and Ackroyd in carrying out their soil survey of the area. The mean heights are derived from the

measurement of five trees at each sampling point. Exceptional trees, such as those obviously used in beating up, were rejected.

The topographical data had already been recorded for the soil survey lines and, with the permission of the surveyors, the data relevant to the sampling points were taken from their records.

It was not possible to collect any detailed ecological data during this work, but brief notes of the vegetation were taken at the time of sampling for height and soil depth. *Pteridium aquilinum* and *Agrostis* spp. with *Festuca ovina* or *Pteridium aquilinum* and *Holcus mollis* with or without *Scilla nutans* provided the typical dominant vegetation on the brown earth soils. *Vaccinium myrtillus* and *Calluna vulgaris* occurred on the steeper slopes where the shallower soils were found and also, to an increasing extent, at the higher elevations within the brown earth area. This seems to be correlated with the increasing degree of degradation which typically occurs in soils of this type in this forest, with increasing elevation. *Deschampsia flexuosa* is also often abundant on these more degraded soils.

Typical dominant plants on podsols are *Pteridium*, much shorter and more sparse than on the brown earths, *D. flexuosa*, *V. myrtillus*, and *C. vulgaris*. The latter species is often especially typical of this soil type. The gleyed podsols, which provide the more infertile soils, are typically dominated by *C. vulgaris* in which *Molinia caerulea*, *V. myrtillus*, and sometimes *Erica tetralis* are more or less abundant. The less infertile areas on these ill-drained soils are marked by a relatively great abundance of *V. myrtillus* and grasses.

A general survey of vegetation seems to indicate that aspect has no important influence on the distribution of vegetation types at the lower elevations. Above 1,500 to 1,600 feet in elevation, however, the bracken-grass type is most typically developed on the warmer aspects, while *C. vulgaris* is the typical dominant of the cooler. The mountain top above 1,800 feet is beyond the planting boundary and outside the scope of this work. The vegetation consists typically of moorland grass types, while the soils are usually gleyed podsols or peat podsols. A series of small springs produces wet areas in the brown earth zone, at about 1,300–1,400 feet elevation and in these *Juncus* spp. and *Deschampsia caespitosa* form the obvious dominants. Sitka spruce has been planted consistently in these small areas.

EUROPEAN AND JAPANESE LARCHES.

The larches are distinguished from the spruce and pine in being confined to brown earth soils (Table II). Japanese larch differs principally from European larch in having been planted to a much greater extent on the most degraded section of these soils: that is on the section which shows the greatest degree of leaching and is nearest in type to a fully developed podsol. The degree of degradation tends to increase with increasing elevation, and, correspondingly, Japanese larch has been planted to an appreciably higher elevation than European larch. On the other hand, it occurs to a less extent on the steeper slopes which, for these species, occur largely at the lower elevations within the part of the forest sampled. European larch, however, occurs to a less extent on the warmer aspects, since these are found at the higher elevations. The two species do not thus occupy

topographical or edaphic situations which are identical in character, although they are part of plantings set on the same hill-side and adjacent to each other.

In this work an attempt is made to isolate the effect of depth of free-rooting material, and elevation, aspect, and slope of ground, on the height growth of the trees. This is done by means of correlation analysis. The complete set of total correlations for the above five factors, as derived from the data for the two larches, is set out in Tables IV and V. These indicate the direct relationships which were to be observed in the forest. They provide, as far as they go, a description of the habitats occupied by the two larches. Thus for European larch the significant correlations show that, on the average, the mean height of the crop decreases as elevation increases; that depth of free-rooting material increases as elevation increases and aspect becomes hotter (taking into account the data given in Table I); that aspect becomes hotter as elevation increases; and that, finally, slope decreases as elevation increases and aspect becomes hotter. A comparison of the total correlations for Japanese larch with those for European larch shows that the two differ appreciably. For example, with Japanese larch there is a significant negative correlation between slope and mean height and the latter factor is significantly correlated with depth of free-rooting material. There are, on the other hand, no significant correlations between this depth and the topographical factors, nor between aspect and slope. But the positive correlation between slope and elevation shows that the steeper slopes tend to occur at the higher elevations, which is the opposite of what is indicated for European larch.

The chief interest in these total correlations lies in the relationships indicated between mean height and the other four factors. Their value is, however, limited because each of the correlations involving mean height is, in reality, a reflection of a resultant effect in which other factors than the one immediately under observation take part in determining the observed changes in mean height, the dependent variable. Thus the relationship between mean height and depth of free-rooting material will be affected by the distribution of this depth with regard to the topographical factors of elevation, aspect, and slope. With European larch, the greater depths are significantly associated with the higher elevations and the warmer aspects. There is, however, a negative correlation between mean height and elevation, and it may be demonstrated that this is usual within any one topographical type of country, where the soils are derived from generally similar parent material. It may thus be expected that an increase in elevation will have a depressing effect on rate of growth. As the deeper soils occur largely at the higher elevations it may also be expected, *a priori*, that the insignificant total correlation between depth of free-rooting material and mean height is not a true reflection of the relationship between these factors but is a resultant effect due, at least in part, to the association of the deeper soils with the higher elevations. This argument is strengthened by observing that with Japanese larch there are no relatively high or significant correlations between depth of free-rooting material and the topographical factors, and that there the total correlation between this depth and mean height is positive and significant, confirming what had been demonstrated before from other data, as mentioned above.

It is plain, therefore, that one of the necessities in correlation analysis is to isolate the influence upon the dependent variable, in this case mean height, of any one of those factors which are suspected to determine its amount, so that it may be seen what the effect of this factor alone will be if the influence of the other complicating factors is held constant. This is done, mathematically, by determining the partial correlations for the factors concerned. The partial correlation coefficients for mean height with the edaphic, and the three topographical factors, are set out in Table VIII, and the related partial regression coefficients are also given. These give the change to be observed in mean height with unit change in the correlated factor. The sign attached to the coefficients indicates whether the dependent variable, mean height, increases or decreases in value with an increase in value of the correlated factor. The partial correlation coefficients for European larch reveal a significant and positive correlation between depth of free-rooting material and mean height, and significant and negative correlations between elevation and slope and mean height. The effect of aspect remains, however, insignificant. It is to be noted that the completely insignificant total correlation with depth of free-rooting material has been changed into an appreciable and significant partial correlation, thus confirming the conclusion reached above. Also, all the significant partial correlations are higher than the corresponding total correlations. This demonstrates the common experience that direct observation in the field may give one an appreciably and sometimes a very erroneous view of the relationship between growth and any one environmental factor affecting it. Table VIII also shows that, with Japanese larch, significant partial correlations are obtained between mean height and depth of free-rooting material and elevation, in both cases their value being higher than the corresponding total correlations; but that the significant negative total correlation with slope has been changed into a lower and insignificant partial correlation. Also, the appreciable total correlation with aspect becomes a completely insignificant partial correlation.

The differences in value between similar correlation coefficients for the two species of larch are, at least in part, a reflection of the different distribution of soil depths within the regions occupied by them and of the different topographical layout of these regions. They may also reflect differences in the constitution of the two species, but it is not possible to distinguish the effect of these with the limited data available. On the other hand, the partial correlations between mean height and depth of free-rooting material, elevation, and slope bear the same sign in each case for the two species, indicating that the reaction of each to changes in any one of the factors is similar as regards direction. The insignificant correlations with aspect do not indicate that change in aspect never has any significant effect upon rate of growth, but merely that this is the case in this particular part of Mynydd Ddu Forest.

It would be possible, with the aid of the partial regression coefficients, to calculate a mean curve showing the manner of change in mean height with change in amount of any one of the correlated factors. One could thus calculate the mean height of either species of larch, at the age for which the measurements have been taken, at any elevation between the limits within which the observations have

been taken, the factors of depth of free-rooting material, aspect, and slope being held constant at any chosen point within these same limits. The effect upon growth of change in topographical, edaphic, or any other type of factor which can be measured quantitatively can be examined in this way. This is one of the uses in fundamental silvicultural research of correlation and regression analysis.

It should be noted that the significance of any particular correlation coefficient depends partly on the number of observations upon which it is based. Thus it may be that some of the correlations recorded in Tables VIII and IX as insignificant refer to real, if comparatively slight, effects and have not resulted merely from the errors which inevitably arise in sampling. This may easily be true, for example, for the partial correlation between slope and height growth in the case of Japanese larch.

SCOTS PINE AND SITKA SPRUCE.

These species form a relatively comparable pair. Table I shows that they have both been planted only above 1,400 feet and are thus absent from the lower slopes where European larch mainly occurs. The spruce occurs on steeper slopes than the pine and to a preponderating extent on cooler aspects. The two species have been planted on similar soil types (Table II), but most of the spruce are on brown earths while most of the pine are on podsolized soil. Spruce are shown as alone occurring on the gleyed podsol, but actually this type of soil, on which growth is consistently poor, occurs to some extent in the type designated as podsol within the Scots pine area. A relatively deep layer of raw humus is one of the characteristics of this gleyed podsol, and it was for this reason that depth of this material was isolated as a factor in analysis.

The total correlations for these species are given in Tables VI and VII. In those with mean height the two species show a certain unity in the significant negative correlations with depth of raw humus and the significant positive correlations with depth of free-rooting mineral soil. Also both show the related significant negative correlation between depth of raw humus and depth of free-rooting mineral soil. The inter-correlations between the topographical factors are significant and of the same sign, but there are appreciable differences in the correlations concerning the edaphic factors. The most important of these are, perhaps, those between the correlations of slope with the two edaphic factors. There is a significant tendency in the Scots pine region for the greater depths of free-rooting mineral soil to occur on the steeper slopes and the greater depths of raw humus on the less steep slopes, but no such tendency is shown significantly in the case of Sitka spruce.

The partial correlation and regression coefficients involving mean height are given in Table IX. With Scots pine the only significant partial correlations are those with the edaphic factors; the sign for these remains the same as with the corresponding total correlations. The partial regression coefficients show that change in depth of raw humus has a much greater effect upon growth than change in depth of free-rooting mineral soil. With Sitka spruce there are no significant partial correlations, but that between mean height and depth of raw

humus is nearly significant. As noticed before, it is quite possible that some of the lower correlations indicate real effects which it is not possible to detect significantly with the limited number of observations.

The key to the differences between the two species lies, at least in part, in the relationships to be observed between depth of raw humus, the topographical factors, and soil drainage type within the regions occupied by them. The Scots pine occur on a site the lower part of which has a relatively gentle slope of from 7 to 12 degrees, while the upper part has a steeper slope of about 20 degrees. The aspect changes fairly consistently towards the south as the ground rises. The more infertile soils, on which the greater depths of raw humus occur, are situated on the lower and more gently sloping part. The partial correlations show that growth is mainly influenced, in this site, by soil conditions, the topographical factors being relatively unimportant. Table VI shows, however, that there are significant and positive total correlations between elevation, aspect, and slope; that is, that as elevation increases, on the average, aspect becomes hotter and slope steeper. None of the poorer soil occurs on the more elevated and steeper slopes which also show the hotter aspects, and, because of this, growth which relatively is consistently good is associated with them. This is the reason for the significant positive total correlations between mean height growth and the topographical factors. The partial correlation takes this into account and gives a more accurate estimate of their real effect on growth. It is to be noted, however, that the partial correlation coefficient for elevation with mean height remains positive, as does that for slope, whereas with the other three species (Tables VIII and IX) these same coefficients are all negative. This probably indicates that soil factors other than the two which have been observed have still to be taken into account and that, when this has been done, the drop in height growth with increasing elevation, which is to be regarded as normal in this country, will be shown, providing the change in elevation is sufficient to exhibit it.

The case of the Scots pine is comparatively simple because conditions for growth consistently become less favourable as raw humus increases in depth or free-rooting mineral soil decreases in depth. Moreover, only two types of water régime are involved, the one freely draining and associated with good growth, the other slowly draining and associated with poor growth. This is not the case with Sitka spruce, for which species four different types of water régime seem to be involved (Fig. 2). Firstly, there are Sitka spruce growing on fresh, freely draining soils and of relatively good rate of growth; secondly, there are the spruce of equally good growth to the first class, on moist soils bearing 2–4 inches of raw humus and showing *Juncus* or *Deschampsia caespitosa* among the ground vegetation; thirdly, there are the poorly growing spruce situated on soils dominated by *Calluna* and *Molinia* and having a deep layer of raw humus, with strongly impeded drainage in the subsoil; and, further, there are the poorly growing spruce situated on relatively dry stony soils marked by short bracken and bilberry and having sometimes a moderate but sometimes a very slight raw humus layer. The failure in the analysis to show significant correlations is to be explained by this confusion of edaphic situations. One is actually dealing, in statistical language, with a

stratified universe in which the different strata need to be distinguished if a useful analysis is to be made. This is illustrated in Fig. 2, where vegetation types are also indicated. Figures 3 and 4 set out the similar information for Scots pine, showing, however, the relationship between mean height and depth of free-rooting mineral soil as well as depth of raw humus. The diagrams show that at the

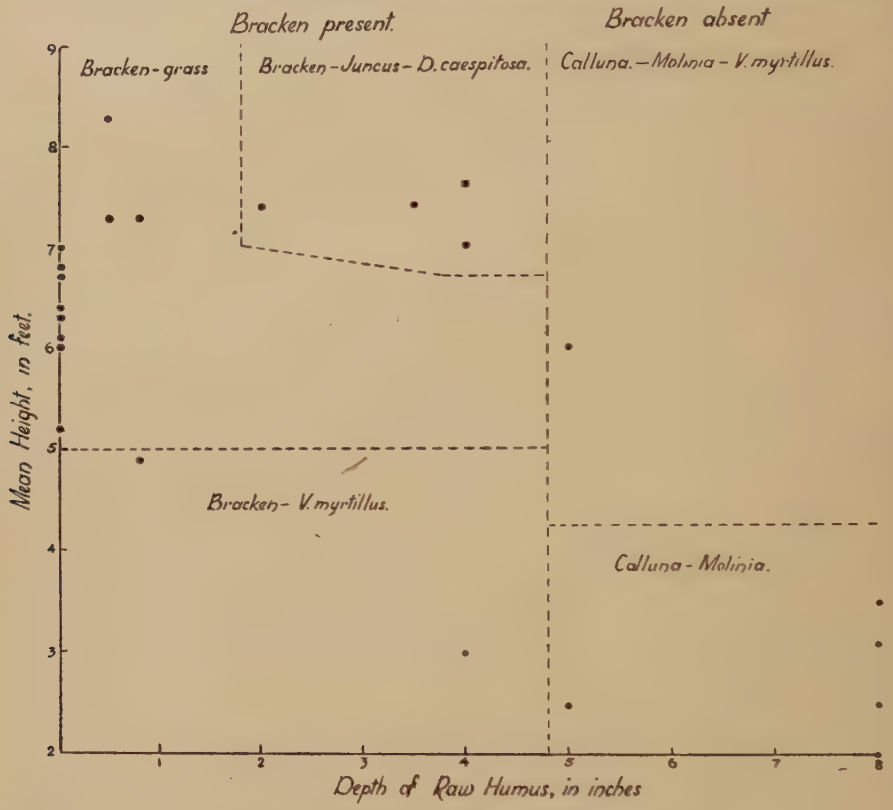


Fig. 2. Mynydd Ddu Forest. Sitka spruce.

time of observation this Scots pine area could have been divided adequately into regions of relatively great or little fertility by reference to the character of the vegetation alone, though whether this was possible before planting was done it is not possible to tell. The absence of the moister but still fresh soil types is obvious in the case of Scots pine; this is to be expected since it is in accordance with general practice to reserve them for spruce in this type of country.

GENERAL COMMENT.

The data presented above show that, providing an area of forest is sampled with sufficient regard to its characteristics as providing an environment for the growth of trees, it is possible to demonstrate the relative influence upon growth of any of these which it is possible to express numerically. It is not pretended that in this way a complete mathematical analysis demonstrating the influence upon growth

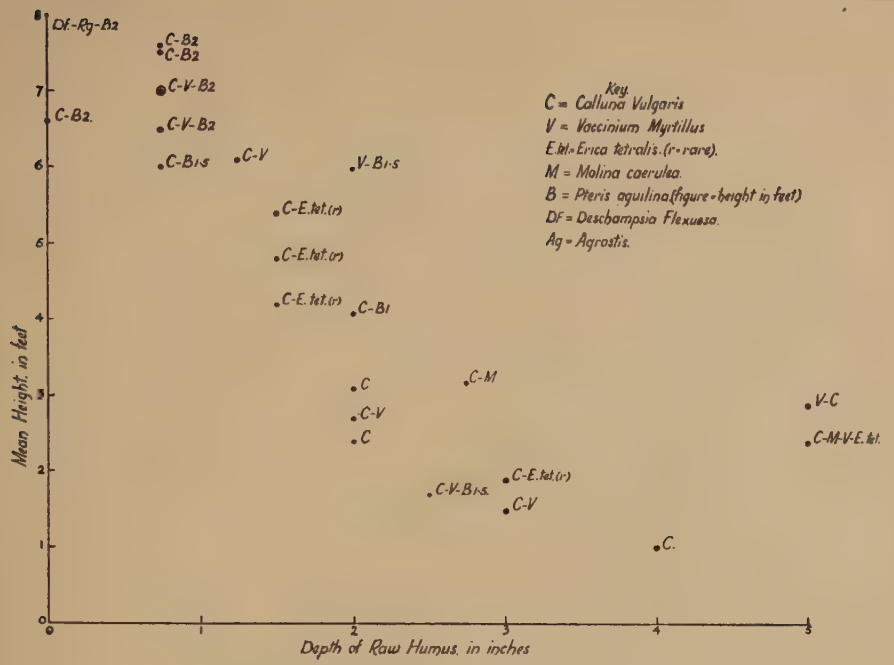


FIG. 3. Mynydd Ddu Forest. Scots pine. Planted 1936.

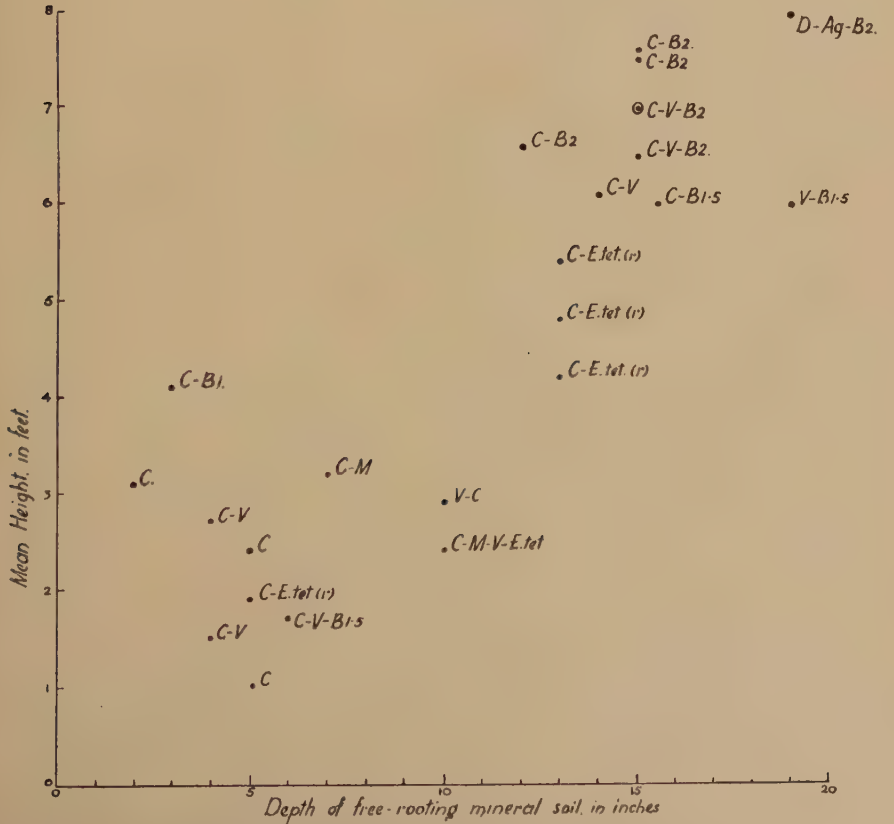


FIG. 4. Mynydd Ddu Forest. Scots pine. Planted 1936.

of all factors of an environment is obtained. All that one does is to demonstrate the reaction of growth to changes in certain measurable and usually interrelated factors, each of which may be merely a mask for a complex of more fundamental factors which has not yet been analysed or measured, or which it may be difficult so to treat. An analysis of correlation and regression, such as has been demonstrated to some extent above, will thus often be merely the first step to a more fundamental investigation.

The truth of this argument will be obvious if any of the factors chosen for the above analysis are considered. Thus the factor 'depth of raw humus' is merely a convenient means, in our present state of knowledge, of referring to various types of soil flora and fauna upon which the rate and type of decay of organic residues depend and which are themselves determined by underlying physical and chemical conditions. Similarly 'depth of free-rooting material' refers to opportunities for root absorption which change with changes in depth of the soil so characterized. The attributes of these opportunities are themselves unidentified and unmeasured. Nevertheless the analysis shows that something of real significance in determining rate of growth is associated with them, and this is the first step towards a proper understanding of their character. The topographical factors of elevation, aspect, and slope are to be regarded similarly; e.g. mere change in elevation is in itself of no particular significance; the changes in climatic and edaphic conditions which accompany it contain the factors of real importance in determining rate of growth.

It is inevitable that if problems in fundamental silviculture are to be provided with answers which are not largely expressions of opinion, quantitative expression with subsequent mathematical analysis must be resorted to: this provides the excuse for this paper which, it is hoped, may interest others in this type of research. For it is only by thinking in terms of quantities, wherever possible, that fundamental silviculture can bring its proper influence to bear in forest economy.

Thanks are due to Mr. C. G. T. Morison and Miss B. I. Ackroyd for the use of data relating to topographical factors, and to Messrs. Nimmo and F. H. Jones for assistance in the collection of other field data. It is also desired to acknowledge gratefully the co-operation of Mr. R. G. Sanzen-Baker, Research Officer for England and Wales, Forestry Commission, in arranging for Mr. Nimmo to take part in the field work, and to the forest staff for their kind help upon all occasions.

The analysis on which this paper is based was carried out by means of the methods described by Goulden (1). Further examples in correlation analysis, in forestry, will be found in the paper by Herrick (2), while descriptions of methods and references to Continental forestry literature concerning correlation problems are given by Hudeczek (3).

LITERATURE REFERENCES.

(1) Goulden, C. H.: *Methods of Statistical Analysis*, John Wiley, New York, 1939.

(2) Herrick, A. M.: 'Multiple Correlation in predicting the Growth of Many-Aged Oak-Hickory Stands.' *Journ. For.* xlii, 1944, pp. 812–817.

(3) Hudeczek, Fritz. 'Die Korrelationsrechnung als forstliche Arbeitsmethode.' *Thar. Forstl. Jahrb.* lxxxiv, 1933, pp. 199–218 and 233–250.

3355.32

TABLE I. *Distribution of Observations with regard to Elevation, Slope, and Aspect.*

Species	*Elevation a.s.l. (ft.)*							*Slope (Degrees)*						*Aspect (Degrees)*			
	1,100–1,199	*1,200–1,299*	*1,300–1,399*	*1,400–1,499*	*1,500–1,599*	*1,600–1,699*	*1,700–1,799*	*< 10*	*10–14*	*15–19*	*20–24*	*25–29*	*30–35*	*80–90*	*91–120*	*121–150*	*151–189*
E. larch	6	12	15	5	..	..	..	3	11	8	4	8	4	19	16	3	..
J. larch	1	2	3	4	4	6	..	3	1	10	1	5	..	8	..	4	8
S. pine	..	..	..	5	13	5	..	5	12	..	6	..	..	4	..	12	7
S. spruce	..	..	..	2	11	5	5	..	7	9	3	3	1	13	..	5	5

TABLE II. *Distribution of Observation Points between Soil Types.**

Species	*Brown earths*				*Podsol*	*Gleyed podsol*
	Normal	*Slightly degraded*	*Degraded*	*Very degraded*		
E. larch	5	3	16	1	..	..
J. larch	..	6	3	11	..	..
S. pine	..	1	3	3	16	..
S. spruce	1	3	2	10	2	5

* This is the 'soil type' as mapped. It is a complex in which soils of the group indicated are present as the dominant type, but not necessarily to the exclusion of other types: e.g. there are indications that gleyed podsols occur in the podsol area occupied by Scots pine.

TABLE III. *Range of Observations concerning.*

Species	*Mean height (feet)*	*Depth of free-rooting material (mineral soil)*	*Depth of raw humus*
E. larch	7·9–17·2	6–32	
J. larch	5·3–20·3	12–23	
S. pine	1·0–7·6	3–19	0–5
S. spruce	2·5–8·3	0–28	0–8

TABLE IV. *European Larch, Mynydd Ddu Forest: Total Correlations estimated from Data collected in 1942 and 1943.*

Factors	*Factors* 1	2	3	4
5	−0·30	−0·22	−0·39*	−0·40*
4	−0·09	+0·63*	+0·63*	
3	−0·43*	+0·59*		
2	+0·040			

TABLE V. *Japanese Larch.*

Factors	*Factors* 1	2	3	4
5	−0·44*	+0·15	+0·47*	−0·09
4	−0·33	−0·07	+0·49*	
3	−0·63*	+0·19		
2	+0·47*			

* The coefficients marked so are significant.
Factor 1 = Mean height.
„ 2 = Depth of free-rooting material.
„ 3 = Elevation.
„ 4 = Aspect.
„ 5 = Slope.

TABLE VI. *Scots Pine.*

Factors	*Factors* 1	2	3	4	5
6	+0·59*	+0·57*	−0·35	+0·60*	+0·67*
5	+0·61*	+0·37	−0·71*	+0·96*	
4	+0·54*	+0·25	−0·68*		
3	−0·81*	−0·58*			
2	+0·86*				

TABLE VII. *Sitka Spruce.*

Factors	*Factors*				
	1	*2*	*3*	*4*	*5*
6	−0·17	−0·09	−0·16	+0·73*	+0·53*
5	+0·12	+0·28	−0·33	+0·59*	
4	−0·16	+0·24	−0·29		
3	−0·56*	−0·66*			
2	+0·50*				

* The coefficients marked so are significant.
Factor 1 = Mean height.
„ 2 = Depth of free-rooting material (mineral soil).
„ 3 = Depth of raw humus.
„ 4 = Elevation.
„ 5 = Aspect.
„ 6 = Slope.

TABLE VIII. *Partial Correlation Coefficients and Regression for Mean Height with Depth of Free-Rooting Material, Elevation, Aspect, and Slope.*

Species	*Factor correlated*	*Partial correlation coefficient (rab. cde.)*	*Standard error (rab. cde.)*	*Partial regression*	*Number of observations*
E. larch	Depth of free-rooting material	+0·49	0·153	+1·96 in. per inch	38
	Elevation	−0·71	0·122	−1·87 ft. per 100 ft.	
	Aspect	−0·07	0·174	−0·82 ft. per 100°	
	Slope	−0·63	0·135	−1·49 ft. per 10°	
J. larch	Depth of free-rooting material	+0·81	0·152	+7·58 in. per inch	20
	Elevation	−0·70	0·184	−1·67 ft. per 100 ft.	
	Aspect	+0·015	0·258	+0·07 ft. per 100°	
	Slope	−0·23	0·25	−2·5 ft. per 10°	

For 38 observations: $r = 0{\cdot}3246$ when $P = 0{\cdot}05$ and $0{\cdot}4182$ when $P = 0{\cdot}01$.
For 20 observations: $r = 0{\cdot}4683$ when $P = 0{\cdot}05$ and $0{\cdot}5897$ when $P = 0{\cdot}01$.

Table IX.

Species	*Factor correlated*	*Partial correlation coefficient (rab. cdef.)*	*Standard error (rab. cdef.)*	*Partial regression*	*Number of observations*
S. pine	Depth of free-rooting mineral soil	+0·72	0·169	+3·12 in. per inch	23
	Depth of raw humus	−0·56	0·200	−8·30 in. per inch	
	Elevation	+0·29	0·233	+1·26 ft. per 100 ft.	
	Aspect	−0·26	0·234	−2·15 ft. per 100°	
	Slope	−0·19	0·238	+0·52 ft. per 10°	
S. spruce	Depth of free-rooting mineral soil	+0·24	0·235	+0·78 in. per inch	23
	Depth of raw humus	−0·44	0·218	−3·69 in. per inch	
	Elevation	−0·34	0·228	−0·75 ft. per 100 ft.	
	Aspect	+0·17	0·239	+0·72 ft. per 100°	
	Slope	−0·045	0·242	−0·16 ft. per 10°	

For 23 observations: $r = 0{\cdot}4438$ when $P = 0{\cdot}05$ and $0{\cdot}5614$ when $P = 0{\cdot}01$.

GROUP REGENERATION IN AMENITY WOODLANDS AT ALICE HOLT FOREST

By F. C. BEST and J. M. ROSS

(*Forestry Commission*)

ORIGIN OF PLAN.

ALICE HOLT FOREST lies in the north-east of Hampshire, occupying part of a plateau which rises to 415 feet above sea-level. The geological formation is Gault clay (Cretaceous), and the rainfall averages 30 inches per annum. Alice Holt has been a State forest for several hundred years, but the greater part of it was not enclosed or systematically planted until about 1820, when oak was extensively planted with the object of providing timber for naval shipbuilding.

In 1919 a start was made to regenerate 147 acres of woodland adjoining Alice Holt Lodge which was let on a long lease at a good rent and whose amenities it was desirable to maintain.

DESCRIPTION OF AREA.

The 147 acres were described as the Amenity Circle. The crop was almost pure oak, practically even-aged, and resulting from a planting made in or about 1820. Little is known of the planting, but it is believed that large transplants comparatively widely spaced were used and a small proportion of Spanish chestnut was mixed with the oak. In 1919 there were still a few conifers, Scots pine and European larch scattered about, with occasional European silver firs and deodars on the ride sides. It is possible, therefore, that conifers were used to nurse up the oak. In accordance with the custom of the nineteenth century the plantations were heavily thinned for poles and oak bark (the site of the old bark barn is still apparent) until the eighties, and nothing further was done until 1919.

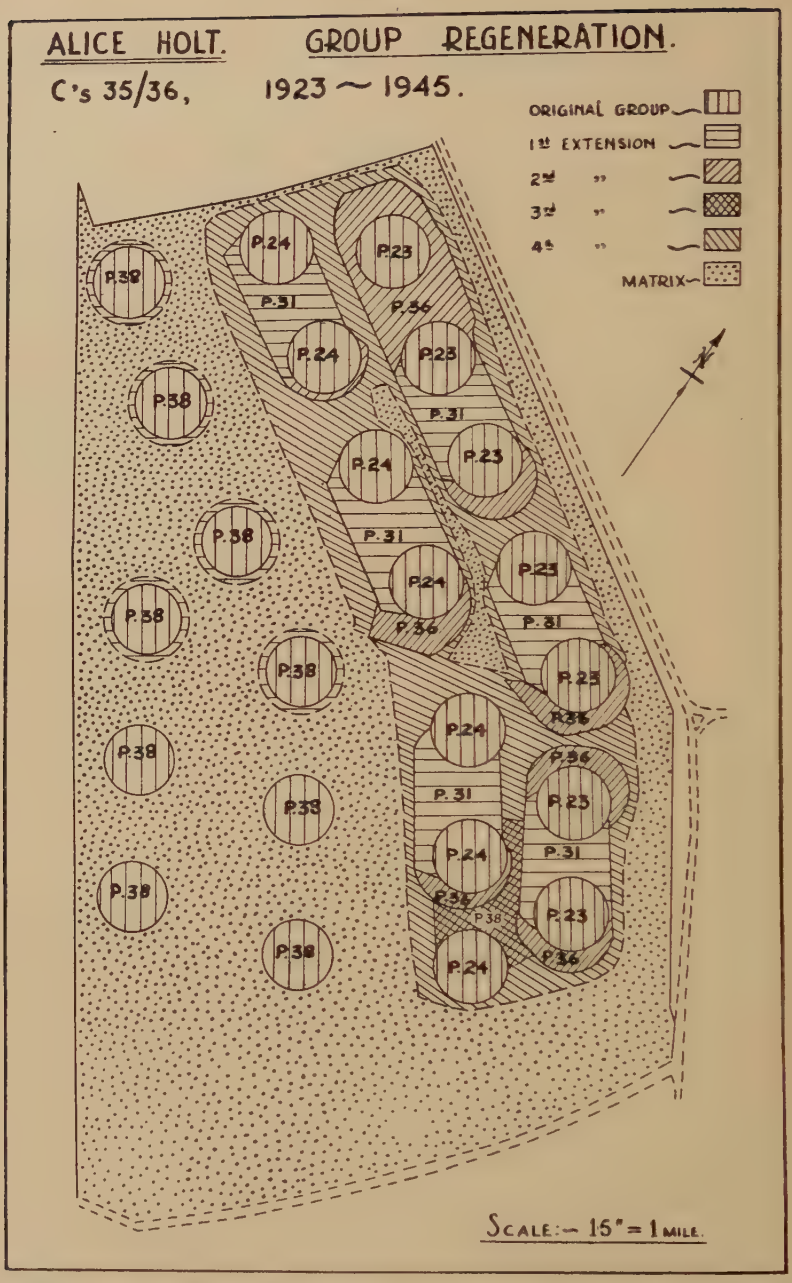
The crop then consisted of about 50 oak to the acre, averaging approximately 10 inches quarter-girth at breast height and approximately 60 feet total height. The volume per acre averaged about 1,200 cubic feet, Hoppus measure. There was a very thin crop of chestnut underwood; the dominant surface vegetation was low bramble and coarse grasses, except at the south end where they were replaced by bracken.

The soil is a sticky loam with much flint gravel, overlying Gault clay at about 18 inches depth. The soil is heavier to the south (bracken areas), where also the growth of oak has been poorest. By modern standards the land was very heavily drained at the time of planting.

The site is an almost level plateau (elevation about 400 feet above sea-level), sloping slightly to the west.

ORIGINAL PROPOSALS.

These were to regenerate by groups, using various species—both hardwoods and conifers—in order to secure a diversity of woodland. The individual groups were not to exceed $\frac{1}{8}$ acre in extent, and 40 groups were to be started in the first 10



years. The first groups were in sets of 4, spaced at about 4 chains (88 yards), centre to centre. The plan shows the arrangement of a few of them. The further intention was to enlarge the groups as the new plantations required more light until ultimately adjacent groups coalesced.

While not adhering strictly to the prescriptions of 1919, the work has in fact

proceeded substantially on the lines intended. From 1919 to 1938 (20 years) 74 groups covering 24·5 acres were started, and 35 groups involving 11·5 acres had been extended, and of these 19 had been twice extended. No new groups have been started since the war, but in 1945 and 1946 further extensions involving 11 acres were made. The total is therefore 47 acres in 27 years. Of the whole Amenity Circle of 147 acres there remain only 26 acres on which grouping has not yet begun. The attached diagram of parts of Compartments 35 and 36 shows the way in which regeneration has progressed.

SPECIES USED IN PLANTING.

Apart from natural oak regeneration, which has been satisfactorily secured in several groups, the species planted have been oak, sycamore, Douglas fir, beech, ash, red oak, and hornbeam, in roughly that order of frequency. Of these, oak has been the most uniformly successful, followed by Douglas fir and beech. Red oak in one of two plots has done very well, as has the single hornbeam group. Ash has grown only moderately. Sycamore has been the least satisfactory of all—a characteristic which is common with that species when planted pure. The older Douglas fir groups have been thinned once, as have one oak, one beech, hornbeam, and red oak.

Some indication of the rates of growth is given in the table below, together with details of three soil-pits.

Species	*P. year*	*Spacing (feet)*	*Height end 1945 (feet)*	*Age end 1945 (yrs.)*	*Remarks*
D. F.	1919	6×6	52	27	
Beech	1919	4×4	43	27	
Beech	1922	5×5	28	24	
Beech (copper)	1923	5½×5½	40	23	
Beech	1938	5×5	6	8	
Oak	1922	5×5	28	24	
Oak	1924	4½×2	30	22	
Oak	1924	4½×4	28	22	
Oak	1930 (new groups)	4½×2	23	16	Comparative heights show mistake of too narrow extensions
Oak	1930 (narrow extension of P. 24 groups)	4½×2	10	16	
Oak	1931 (extensions)	4½×2	15	15	
Oak	1938	4½×2	7	8	
Oak	1936	4½×2	5	10	
Sycamore	1923	5×5	18–30	23	Very irregular
Sycamore	1931	5½×5½	12–25	15	„ „
Sycamore	1932	5½×5	23	14	More regular under poorest Oak C. 38
Ash	1924	5×5	32	22	
Hornbeam	1924	5×5	40	22	
Red oak	1922	5×5	25	24	
Red oak	1924	4×4	38	22	Under best Oak C. 36

Soil-pit C. 38

Vegetation

Blackberry
Aira caespitosa
Juncus
Bracken

Soil

1½ in. decomposing litter
1 in. mull humus
8 in. dark, stiffish loam
8 in. blue-grey clay with brown mottling showing impeded drainage

Water-table

18 in. stiff heavy clay
(Gault formation)

Soil-pit C. 36

Vegetation

Blackberry
Aira caespitosa
Honeysuckle
Bracken

Soil

1½ in. decomposing litter
1½ in. mull humus
12 in. dark loam with flints
14 in. grey loam with clay and flints
12 in. stiff clay

Water-table

Stiff heavy clay
(Gault formation)

Soil-pit C. 33

Vegetation

Blackberry
Bracken
Honeysuckle
Aira caespitosa

Soil

1½ in. decomposing litter
2 in. mull humus
6 in. dark loam
12 in. very gravelly loam

Water-table

16 in. gravelly clay
(Gault formation)

PLANTING AND WEEDING.

Oak, as indicated above, were planted as a rule at 4½ feet by 2 feet and very well-grown crops are the result.

Following the felling of a group, weed growth is somewhat rank. The brambles and briars develop strongly, sallows tend to seed in, and chestnut coppice grows rapidly. Thorough weeding was therefore necessary, and when it was neglected or half-hearted (as in some of the early plots) the young plants suffered considerably. At a later stage honeysuckle is also a nuisance and must be cut back.

DEVELOPMENT OF THE GROUPS.

Growth is strongest in the middle and the marginal trees tend to show signs of suppression in the course of 4–5 years. This is well shown in the accompanying Plate which illustrates two stages in the development of a sycamore group. By the eighth year the effect of partial overhead shade on oak is very marked. On the average an extension of the group is desirable about 5 years after planting.

Photo. B. C. Adkin

Group of Sycamore a few years after planting, showing the outline of another group in the background

Photo. B. C. Adkin

A young Sycamore group after extension

PLATE I

Each species, of course, varies according to its demands for light, but the tendency has been to defer extensions too long. The method of effecting extensions is indicated on the accompanying plan.

AMOUNT OF TIMBER REMOVED.

At the time the first groups were made the average volume per acre was approximately 1,300 c. ft. The latest fellings (1945) have been about 2,000 c. ft.

Approximate details are as follows:

	Cubic feet	*Value* £
30 acres felled prior to 1931 yielded	39,000	1,950
6 „ „ 1936 yielded . .	9,650	490
11 „ „ 1945 „ . .	23,750	2,360
	72,400	£4,800

DISCUSSION OF THE METHOD.

The method has been successful in preserving the amenity of the Lodge and at the same time in breaking up the single-age class and in providing produce.

As a silvicultural method it has certain advantages and drawbacks. In the first place it is only applicable where the fencing of every individual regeneration area against stock or rabbits is not necessary. Further, extraction has to be reasonably easy. Another disadvantage is the detailed attention which each group requires if the best results are to be obtained.

The advantages lie on the side of protection of the young crop against exposure and frost, and the retention throughout of 'forest' conditions, including the conservation of humus in the soil. These factors are doubtless reflected in the rate of growth, though unfortunately there are no controls to serve as comparisons.

APPLICATION OF THE METHOD.

On the experience gained at Alice Holt it is unwise to start too many groups at one time. The subsequent work of enlarging the groups tends to get out of hand and growth to suffer accordingly. One may easily be committed either to more work than can be comfortably undertaken or to regenerate at a faster rate than is desirable. A common fault is to make the extension of a group too narrow and to plant too close to the old trees.

Care must be taken from the beginning to plan extensions in such a way as to avoid damage to young trees. In a general way this means starting in or towards the middle of a compartment and working towards the main extraction routes.

HOURLY VARIATIONS IN THE INCIDENCE OF FOREST FIRES

By H. L. EDLIN

(*Forestry Commission*)

IT is common knowledge amongst foresters that fires are more prone to start at certain hours of the day than at others, but it is seldom easy to assess the danger periods for any given locality owing to the lack of data over a sufficient period of years.

Records preserved in the New Forest Conservancy of the Forestry Commission, however, extend over a sufficiently wide range of area and conditions, and length of years, to provide adequate material for analysis. Reports on 619 fires have been examined, the great majority of which occurred on unplanted heathland and did no damage. As the point at issue is only the time of the outbreak, the severity of the fires has not been assessed. All were sufficiently large to necessitate a report, which implies that they required extinguishing by forest employees, and that, if left unchecked, they would probably have spread until actual damage resulted.

AREA UNDER REVIEW.

This comprises approximately 78,000 acres in west Hampshire, east Dorset, and the Isle of Wight. The principal vegetation is heather, which is readily inflammable at all seasons of the year after a day or two of dry weather. The area has a small resident population, but is so close to populous centres that it is traversed at all time of the year by large numbers of travellers and recreational visitors. Besides the general public all the other usual fire risks are present, including railways, traction engines, army exercises, incendiarism, controlled burning of heath, and occasional carelessness of workmen. The records available extend from 1926 to 1942. Fires due to enemy action have been omitted.

OCCURRENCE OF FIRES BY HOURLY PERIODS.

This may be expressed as the actual number recorded, as the percentage of the total which this number represents, or as the divergence of this percentage from the theoretical percentage applicable to each hourly period. If the occurrence of fires was evenly spread around the clock, $\frac{1}{24}$th, or 4·166 per cent., would occur in each hourly period; any variation from this frequency represents abnormality. The test of frequency, therefore, is not the actual number of outbreaks in any given hourly period, but the relation which this number bears to the theoretically normal number. Thus, 8·332 per cent. in a certain hour would indicate twice the normal frequency, and 2·083 per cent. would mean half the theoretical normal.

Recorded percentages are tabulated below, and are also shown graphically.

CORRECTION FOR SUMMER TIME.

Summer Time and Double Summer Time were in operation when certain of the recorded fires occurred. But if the times of occurrence are reduced to Green-

wich Time, the table and graph remain substantially the same as before. By Greenwich Time, however, far fewer fires occur in the final hourly period of the day, 11–12 p.m. (10 as against 27). Probably the night dews have become effective in damping down the vegetation at that hour.

SIGNIFICANCE OF THE FIGURES.

Reference to the table and the graph shows that in the early morning, from midnight to 8 a.m., very few fires occur. The percentage over the 8 hours is only 1·28, whereas it should be theoretically 33·33.

During the succeeding 4 hours, between 8 a.m. and noon, there is a gradual increase in frequency, but this is still below normal. The percentage for the 4 hours is only 5·81 against a theoretical probability of 16·66.

After midday there is a sharp increase. Between noon and 2 p.m. fires exceed theoretical normality. Between 2 and 5 p.m. they exceed twice theoretical normality, falling off a little between 5 and 7, but returning to a maximum high peak between 7 and 8. After 8 p.m. there is a steady diminution towards midnight.

Each 24-hour period may therefore be divided into 2 periods of 12 hours each. In the first period, from midnight to midday (i.e. a.m. hours), fires are below the expected frequency, averaging 7·1 per cent. against a theoretical 50 per cent.

In the second period, from midday to midnight (i.e. p.m. hours), when again some 50 per cent. of all fires might theoretically be expected, actually 92·9 per cent. occur. In other words, forest fires are 13 times as likely to occur after noon as they are before noon.

The possibility that the figures on which these conclusions are based might be due to some chance aggregation of exceptional figures has been investigated. The data have been analysed further under two heads: Factors causing fires, and Forest units at which fires occurred. Certain causative factors are naturally limited to certain hours of the day, e.g. traction engines seldom run after 6 p.m., but where a causative factor operates throughout the 24 hours the distribution of resultant fires approximates to the graph for the total of outbreaks observed. Graphs for individual forest units, where a sufficient number of fires has occurred, also follow the main graph.

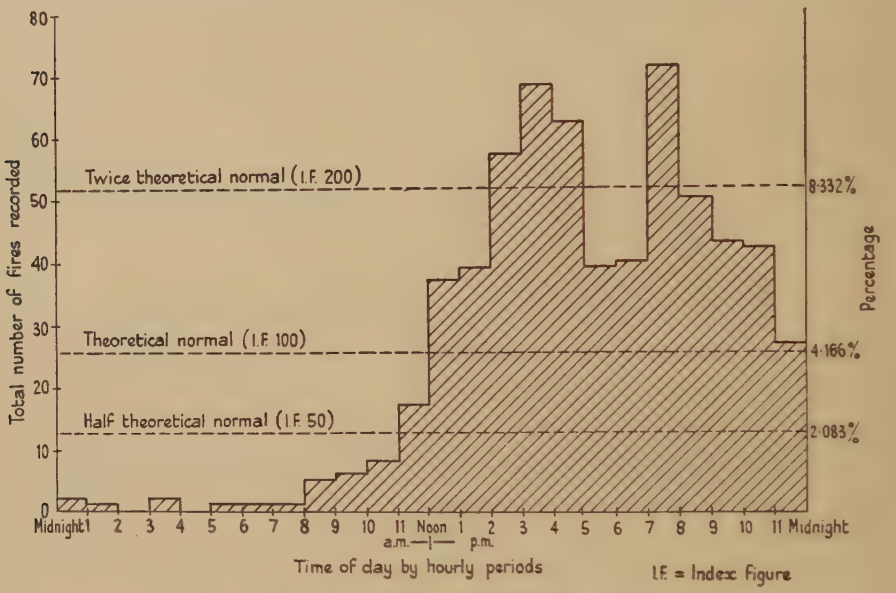
FACTORS AFFECTING FREQUENCY.

There appear to be two main factors affecting the probable frequency of forest fires from hour to hour. The first and most obvious one is the weather, which may be termed a permissive factor, since it does not cause fires but only causes conditions which permit fires to spread. Weather is clearly responsible for the paucity of fires before midday. Even in dry weather the vegetation is normally kept damp by night dews until dried by the midday sun. These factors vary in effect with Greenwich Time or 'sun time'.

The second factor is a causative one and is the degree of human activity on the area during any given hour of the day. Different types of activity vary in intensity during different times of day. Thus traction engines caused no fires after

6.30 p.m., Army exercises none after 7 p.m., and workmen and intentional burning of vegetation none after 8 p.m. Railways and incendiarists continued to cause fires until 10.30 p.m., but between 10.30 p.m. and 8 a.m. fires were only due to the general public or to causes which could not be traced.

Taking the two factors together, the high peak for fires between 2 and 5 in the afternoon is readily understood. Dry weather conditions coincide with a time of day when all the causative factors are in operation. At 5 p.m. work normally ceases, and the diminution of activities likely to cause fires is reflected by the drop


Total number of fires recorded
Twice theoretical normal (I.F. 200)
Theoretical normal (I.F. 100)
Half theoretical normal (I.F. 50)
8·332%
4·166%
2·083%
Percentage
Midnight 1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Midnight
a.m. p.m.
Time of day by hourly periods
I.F. = Index figure

in observed frequency. The gap between 5 and 7 p.m. might be said to represent the 'tea interval'. After 7 there is a sudden increase in fires, due no doubt, in part at least, to the large number of countrymen who habitually take an evening stroll, and smoke an evening cigarette, at this hour. After 8 the steady drop in human activity is reflected by a decrease in fires. At midnight human activity virtually ceases, and so do the fires. Human activity varies according to 'clock time'.

PRACTICAL APPLICATIONS.

The graph shows clearly that precautions against forest fires must be most stringently observed during the hours after noon each day. If patrols or look-outs are to be posted, this should be done as early as midday, and the watch maintained until midnight. Fire-fighting equipment, such as lorries, should be held ready in dry weather throughout the afternoon hours.

SUMMARY.

1. The writer has analysed the recorded times of occurrence of 619 fires on Forestry Commission lands in the New Forest Conservancy of Southern England between 1926 and 1942.

2. He finds that only 7·1 per cent. of these fires occurred between midnight and midday (12 midnight to 12 noon) and 92·9 per cent. occurred between midday and midnight (12 noon to 12 midnight).

3. He attributes the variation of frequency partly to weather conditions and partly to the degree of human activity occurring at the hours in question.

4. He concludes that precautions against forest fires should be especially stringent during the afternoon hours.

TABLE

Hourly period	*No. of fires*	*Percentage of total*	*Relation to normal* 4·166% = 100
Midnight–1 a.m.	2	0·32	8
1–2 a.m.	1	0·16	4
2–3 a.m.	–	–	–
3–4 a.m.	2	0·32	8
4–5 a.m.	–	–	–
5–6 a.m.	1	0·16	4
6–7 a.m.	1	0·16	4
7–8 a.m.	1	0·16	4
8–9 a.m.	5	0·80	20
9–10 a.m.	6	0·96	24
10–11 a.m.	8	1·28	31
11 a.m.–Noon	17	2·72	66
Noon–1 p.m.	37	5·92	142
1–2 p.m.	39	6·35	149
2–3 p.m.	57	9·12	219
3–4 p.m.	68	10·98	263
4–5 p.m.	62	9·92	238
5–6 p.m.	39	6·35	150
6–7 p.m.	40	6·54	159
7–8 p.m.	71	11·48	275
8–9 p.m.	50	8·14	199
9–10 p.m.	43	6·98	168
10–11 p.m.	42	6·82	164
11 p.m.–Midnight	27	4·36	101
TOTALS	619	100·00	(2400)

LABOUR COSTS IN ENGLISH FORESTRY SINCE 1824

By J. J. MACGREGOR

(*Department of Forestry, University of Oxford*)

IF there is one thing more than another which distinguishes the economic activities associated with forestry from those of other industries it is the length of the production process. This fact alone makes the estimation of true cost of production extremely difficult. In the span of years between planting and ultimate realization costs are likely to vary considerably from one decade to another. Within the movement of total cost it is reasonable to suppose that the trend of labour cost—which has the greatest direct influence on the cost of forestry operations—is a substantial clue to the measurement of total cost. It is true that the accumulation of interest payments on capital, carried forward at compound rates, will exceed the labour costs in normal circumstances. But, as one of the main objectives of comparable cost studies is to judge the relative efficiency of the technical management, the charge for interest can be conveniently excluded when judging short-term efficiency. For other objectives, such as the determination of the profitableness of a particular rotation, the conception of the Faustmann formula[1] —modified and refined to allow for changing prices and costs—may be adopted.

But whatever the particular objective of economic study in forestry may be, it seems clear and desirable that there should be adequate presentation of historical data on costs and prices. Economists in drawing broad conclusions have to use the best estimates available and have made frequent use of index numbers to trace the trends or movements of many economic phenomena. Observing the need for a link or factor for measurement between one series of costings information and another, the writer of this article attempts to outline an index of rural wages covering approximately the past 120 years. At the same time the obvious limitations and qualifications in the use of such an instrument for measuring historical change are emphasized. Nevertheless, however imperfect it may be, it is hoped that this analysis of rural wages will serve as a convenient record of the past to which the forester probably looks back more frequently than any other comparable type of business man. It is also hoped that the limitations of the study for the direct purpose in mind may call forth further studies on the question of forestry wages and their relation, say, to the Minimum Agricultural Wage rates.

[1] The Faustmann formula is written $S = \dfrac{\mathcal{Y}r + \sum \mathcal{T}a.1.op^{r-a} - C.1.op^{r}}{1.op^{r}-1} - \dfrac{e}{.op}$, where S is the market price of the land; $\mathcal{Y}r$ is the standing value of the final yield in the year r; p is the rate of interest; $\mathcal{T}b, \mathcal{T}c \ldots \mathcal{T}x$ are the standing values of thinnings in the years $b, c \ldots x$; and $\sum \mathcal{T}a \times 1.op^{r-a}$ represents the sum of the value of these individual thinnings carried forward to the end of the rotation at compound interest—it will represent $[(\mathcal{T}b \times 1.op^{r-b}) + (\mathcal{T}c \times 1.op^{r-c}) + \ldots (\mathcal{T}x \times 1.op^{r-x})]$; r is the rotation in years; C is the cost of planting; and e is the cost of annual management. The last item e, which in the formula is implied as an average for the whole rotation, thus assumes a precise knowledge of changing annual costs of management over the whole period of a rotation if the calculation is to be more than an approximate estimate.

From observation on a few private estates, and what might reasonably be expected, there is a close relationship between agricultural wages and the rates paid to forestry workers, although this is a point that might be usefully examined further. Accepting this assumption, it is possible to construct an approximate index of wages applicable to forestry since, over the period under review, from 1824, there is a fair amount of data on the course of agricultural wages. Certain difficulties, however, arise if one tries to trace a rate applicable to Great Britain, or even to England, as a whole, because until recently there was considerable variation in the rates between one region and between one county and another, for reasons that are explained later in this article. It would probably be safe to assume that wages for work in private woodlands were on a par with the local rate for farm work, and that the appropriate county agricultural rate would determine the basis for forestry rates in any particular area.

As it is highly probable that most of the available forest operational costs will relate to comparatively recent times it is proposed here to discuss in slightly more detail the level of rural wages in the period between World War I and World War II. It was in the first of these wars that the State first stepped in to provide a Minimum Agricultural Wage; and since then the statistical evidence, on a county basis, has been more elaborate and precise. It is desirable, however, to trace the approximate course of rural wages over as long a period as possible, and in this connexion the investigator is considerably helped by the research work of Dr. C. S. Orwin and Mr. B. I. Felton,[1] and also by certain parts of Professor Bowley's studies of wages. The writer has brought the relevant analyses up to date and has prepared an index of the unweighted average of the seven divisions of England which have formed the basis of the main analysis.

Certain criticisms must be made about the use of the data. For one thing, although the wages show a general tendency to rise over the period, it must not be inferred that the standard of living of the worker rose at the same rate. Indeed, on the one hand, in times of rural and industrial depression he may have gained because the cost of his requirements was falling more rapidly than his wages; and, on the other hand, in times of rising prices his wages tended to lag behind those prices. The rates described are based on the assumption that a full week has been worked when, in fact, before the Minimum Wage Regulations came into force the worker may have been paid only for the portion of the week in which he was employed. The dangers of relying too much on averages of unweighted data derived from a variety of sources is stressed by the writers of the above article;[1] but, granted the qualifications which they fully discuss, it should be possible to draw general conclusions and to link one lot of costs with another from the facts and figures set out for over a century. In order to appreciate the main reasons for the changes in rates, the significant economic developments affecting employment in rural areas are discussed.

The problem of studying the trend of rural wages in the nineteenth century has not been made too difficult through the lack of evidence, because there are many

[1] Orwin, C. S., and Felton, B. I., 'A Century of Wages and Earnings in Agriculture', *Journal of the Royal Agricultural Society of England*, 1932.

public and private inquiries on this topic. Indeed, the abundance of the information has made generalization rather difficult.

'"Agriculture" is the generic title given to a variety of industries, and the income from each, divisible amongst capital, management and labour, varies with the special conditions attached to each, which may be favourable or otherwise to their relative profitability. And the agricultural labourer is not a specialist in the modern industrial sense of the word, but rather has he a diversity of functions, so that it is difficult to assess the specific productivity of his labour. These factors, however, are disregarded in the main in the assessment of the labourer's worth, and employment in different branches of agriculture, or variety of employment within the same branch of agriculture, has never been differentiated in farm wages.'[1]

Sufficient evidence has been made available to show the rates of wages for certain regions of England and for certain periods, as indicated in the accompanying Table I. The divisions referred to by number in the table are as follows:

Division 1. Cumberland, Westmorland, Northumberland, Durham, Yorkshire, Lancashire, Cheshire.
Division 2. Derby, Nottingham, Lincolnshire, Rutland, Leicester.
Division 3. Warwick, Worcester, Stafford, Salop, Hereford, Gloucester.
Division 4. Somerset, Cornwall, Devon, Dorset, Wiltshire.
Division 5. Cambridge, Bedford, Huntingdon, Northampton, Hertford, Buckingham, Oxford.
Division 6. Hampshire, Sussex, Kent, Surrey, Middlesex, Berkshire.
Division 7. Essex, Suffolk, Norfolk.

In the three-quarters of the nineteenth century covered by the table the conclusion is reached that the cash wage increased from 10*s*. by 5*s*., or by 50 per cent. The twentieth century brought stability at a slightly higher level before the 1914–18 War. Excluding the temporary increases associated with the war and post-war years of 1917 to 1921, the level of these cash wages appeared to have been subsequently stabilized at about three times the rate associated with the eighteen-twenties. In the short space of about seven years since 1939 these levels, in turn, were raised almost two and a half times. Over the whole period from 1824 it will be seen that the gains were not regular and the movements were different in the individual districts.[2]

It is worth while to mention briefly the main causes of these movements in wages from the start of the period. Owing to a variety of causes associated with the slump after the Napoleonic War, for example, the increase in local rates due to the Speenhamland system[3] of bread relief, bad harvests, and rigid rents in the face of

[1] Orwin and Felton, op. cit.

[2] It is probably more convenient to link past trends with the current wage levels by an index when the present basic weekly wage of 80*s*. is put at 100, then it is demonstrated that throughout the nineteenth century and up to the 1914–18 War the index was under 20, and just after that war the maximum point reached was 58 in 1920.

[3] The Speenhamland system owes its name to the village in Berkshire where the magistrates in 1795 met to consider what measures should be taken to alleviate the distress caused by the high cost of living. In the opinion of these men 'the present state of the poor required further assistance than had generally been given them'. The assistance in the interest of equity should vary with the cost of living. A detailed scale was drawn up which related the minimum cost of living to the price of

falling corn prices, farmers as a class suffered a severe financial depression. On the whole, the maintenance of wage rates was helped in the northern areas of the country by the spread of industrialism. Orwin and Felton ascribe three causes for the range in wages in different parts of the country:

'By the year 1824, the Industrial Revolution had already altered the distribution of the economic forces of the country. The northern counties, so long divorced by distance from suitable markets, now found a market for their products close at hand. The rapid development of the factory system, concentrating population around the coal measures, caused a growing demand for food which assured to farmers in and around the districts concerned a more stable market than that enjoyed by those in the south. At the same time the growth of London had a similar effect upon wages in the south-eastern counties.'

Total earnings could not be judged solely on the cash wages, as they covered, on the one hand, seasonal opportunities for extra wages and perquisites and, on the other hand, the rural worker, particularly in the south, lost his common grazing rights through enclosure, and many often lacked suitable cottage gardens. The southern worker was more dependent on his cash wage at the time, while the northern worker was on farms which were growing more profitable things than corn. The latter areas had more cottage gardens and the men lived as boarders, frequently on long hirings of six months or a year. Later on, in the middle of the nineteenth century, the repeal of the Corn Laws exposed the southern and eastern counties to the full effects of Free Trade more than it did the other parts of England. Caird, writing at this time, estimated that the level of wages was about 40 per cent. higher in the north—where there was continuous expansion of industry—than in the south.

In the eighteen-thirties and forties the economic position of the rural worker was affected chiefly by the passing of the Poor Law Amendment Act, 1834, and by the repeal of the Corn Laws in 1846. Before the 1834 Act was passed, wages had been subsidized and this had created a surplus of labour on the land at low wages; and subsequently, although wages tended to increase, able-bodied and married men were affected adversely because, without any subsidized earnings, they had to compete with the relatively plentiful supply of labour. In order to maintain their income at previous levels they required the assistance of their families in the field, and this further added to the competition.

The second half of the century falls conveniently into two equal periods for assessing rural wages levels. The first has on very many occasions been described as 'the Golden Age of British Farming' because many factors combined to raise prices: the country was beginning to reap the reward of being first in the industrial field; a growing industrial population with rising incomes created a growing demand for food; the gold discoveries in California and Australia had an inflationary effect on prices; after the Crimean War England was at peace, while there was

corn. When the loaf cost 1*s*. every poor and industrious man had 3*s*. weekly for his own support whether earned by himself or family, or allowed out of rates, and for other members of his family 1*s*. 6*d*. For every 1*d*. which the loaf rose in price, he was to get 3*d*. and every other member of the family 1*d*. The general spread and popularity of the system first in Berkshire and then throughout the country was reflected in the great increase of the Poor Rate.

political instability in Europe and America; in addition there were improvements in transport which helped to diffuse or distribute the general prosperity at home.

Orwin and Felton mention that during this period cash wages advanced by about 3*s*. per week all over the country, but that the marked distinction between the different parts of the country still remained:

'The determining factors in these district variations were the same as those already noted in the earlier period. In addition, the expansion of urban industry and its localization in the Midlands and north provided farm workers in those parts with alternative employment, while such domestic industries as still existed in the southern half of the country were dying out.

'Moreover, the distribution of rural labour was subject to influences other than those economic, some of which have been noted already. In the north, the supply was small; in the south was an over-supply, complicated by the employment of women and children. The farm servant, hired for the half-year or the year, and receiving wages and board irrespective of weather or sickness, was a prevailing type in the north; the day labourer, stood off when not wanted, was typical of the south. In the east, large-scale farming and machinery exaggerated the seasonal demand for labour, calling into being the gangs required only at certain periods. In the south-west, the redundant population kept the workers' wages low.'

Although there was a larger proportion of allotments in the south, opinions differ about the extent to which they tended to reduce the level of wages. They provided at any rate a distinct addition to the food supply. In the north, where the worker lived in, or where he had some perquisites, the need for allotments was considerably reduced.

In the last quarter or so of the century great changes took place in the organization of farms, and while both landlord's and tenant's capital was halved in value, the farm worker was able to improve his cash wage. The main cause of this trend was that agriculture and other rural businesses had to compete more strongly, particularly in the industrial midlands and northern areas, for their labour supply.

Quoting from the reports of Little and Wilson-Fox in relation to 1892 and 1898 respectively, Orwin and Felton showed that the total weekly earnings, as distinct from cash wages, advanced from the level of 1867–70 by about 2*s*. 3*d*., on the average of all divisions, although in the eastern counties the average gain was no more than 4*d*. per week. These changes and variations again emphasized that higher wages could be paid by those systems of farming which produced livestock products as these were then subject to increasing demand and rising or steady prices. Set against such a measure as the Sauerbeck index of prices for some forty-five commodities it can be appreciated that the rural workers' real wages in the last quarter of the nineteenth century had increased by at least 30 per cent.[1]

[1] There are definite limitations in using the Sauerbeck-Statistic Index Number as an indication of changes in the cost of living, since it deals with wholesale prices which, particularly the raw materials, included in the index, are more liable to fluctuation than retail prices. The index does, however, give a broad measure of the movement of prices and emphasizes the fact that in 1946 the relation of rural wages to wholesale prices was more favourable than at any previous year of the period under review in this article. Rural wages have long been regarded as being too far out of line with industrial wages. Accordingly during the period of the recent war the index of these wages

The evidence suggests a stability of wages in the first decade of the present century and then an appreciable rise in the years just before World War I. On the other hand, the cost of living was moving upwards, and it is clear that the real wages of the worker were not maintained at the level reached at the end of the century. In the early years of the war, wages rose slowly—much more slowly than the cost of living. The average weekly wage customarily quoted for the years before World War I was 15*s.* 8*d.* and by the summer of 1917 this had risen to 23*s.* 7*d.* or 40 per cent. In the same period the cost of living advanced by more than 75 per cent.

The Corn Production Act of 1917 assisted farmers directly by fixing cereal prices at levels which encouraged production at a time when U-boat attacks had increased in ferocity and were gravely endangering the food supplies. The Act also helped the farm worker by stipulating a minimum wage of 25*s.* per week, but in view of the rapid increase in the cost of living the minimum was quickly raised by the Wages Board on the advice of the County Wages Committees which central and local bodies had been set up by the 1917 Act. A year later 30*s.* was the lowest minimum weekly wage in England for 54 hours in summer and 48 in winter. In addition, provision was made for overtime and for special classes of workers such as cowmen, wagoners, &c.

As Table 1 shows, the maximum reached in the post-war period was in August 1920 when wages in individual counties ranged from 42*s.* to nearly 52*s.*—rates which lasted for a year. In 1921 the Corn Production Act was repealed and the Wages Board machinery ceased to exist. Until 1924 wages were supposed to be regulated by the voluntary Conciliation Committees, but they were largely inoperative. From the end of 1922 to 1924, when the Agricultural Wages (Regulation) Act was passed, the average wage remained about 28*s.*, although the rates were lowest in East Anglia and the west Midlands at 25*s.*, compared with 35*s.* in the northern counties.

As Orwin and Felton point out;

'The return to *laissez-faire* from 1921 to 1924, proved once more that in an uncontrolled market the northern farm worker could command a higher wage than the southern. At the end of the Wages Board period, the difference between the highest and the lowest counties was no more than 3*s.* per week; in 1924, wages in the northern counties at 31*s.* 10*d.* were more than 6*s.* higher than the average rate prevailing in Essex, Suffolk, and Norfolk.'

This tendency was reversed under the operation of the 1924 Act and the extreme variations tended to be narrowed once more as under the operation of the 1917 Act. The immediate effect of the 1924 Act was to raise the average wage by more than 3*s.* per week, and at this level stability appears to have been maintained until the severe economic depression of the early thirties had the inevitable repercussion on wage rates and employment. Although wage rates only fell by a shilling or so, the length of the average working week was slightly increased. From 1935 onwards a distinct rise in wages is apparent and, as the data show, the minimum wage level of 70*s.* at March 1945 stood at double the rate at

having risen considerably higher than for any other industry, with the possible exception at certain times of coal-mining, this rise should go some way to alter this grievance. (See Table 3, p. 42.)

the beginning of 1939. In July 1940, for the first time, a national minimum wage was introduced at 48*s*., and this was raised successively to 60*s*., 65*s*., 70*s*., and 80*s*., in December 1941, December 1943, March 1945, and July 1946 respectively.

It is perhaps worth emphasizing here again that the rates already discussed refer to basic or minimum wages, and that the actual earnings may vary from these amounts. In agriculture, for instance, there is evidence to show that, in the decade before the 1939 war, ordinary farm workers earned between 2*s*. and 3*s*. above the minimum wage, while stockmen and horsemen earned a further 5*s*. to 6*s*. and 3*s*. to 4*s*. more than the ordinary worker, respectively. These additions to the minimum arise in large part from the special nature of the work, which involves a certain amount of overtime payments, and the opportunities in certain operations to earn piece rates. From observation it is probable that normally there is less need for overtime work in forestry, although there are many operations which may lend themselves to payments of piece rates. Here, again, there is scope for investigation of the extent to which forestry workers' earnings differ from the Agricultural Minimum Wage.

For the more recent period since 1918 it is possible to give a little more detail about the hourly rate paid. In the year-books of the National Farmers' Union an index has been prepared of the approximate increase in wages, allowing for changes of hours per week, from the pre-1914 level, when a weekly wage of 18*s*. (16*s*. 3*d*. cash and 1*s*. 9d. perquisites) is assumed for a 58-hour week. This information has been adapted to show in Table 2 the actual hourly rate for the minimum wage which has applied to a different number of basic hours from year to year. On the whole, the average number of hours has exceeded 50, but under the most recent awards these have been reduced to about 48 all the year round.[1] In addition there has been the complication, for comparative purposes, of the passing of the Holidays With Pay Act in July 1938. The net effect of this Act appears to give the worker the equivalent of one week's holiday with pay in each year. This complication would seem, therefore, to have the effect of reducing the effective working week by a further hour and of slightly increasing the cost of the hourly rate for the remainder of the year, but no allowance is made for these effects in the table. Another effect of the reduced number of working hours is that, as far as farmers are concerned, more hours of overtime may have to be paid than formerly because livestock tending and urgent harvest operations still require long hours. It is felt, however, as already indicated, that forestry operations are unlikely to involve much overtime payment, as the work can be more evenly spread over the year.

The special wages and conditions agreements for the workers of the Forestry Commission are worthy of some elaboration.

Before the introduction of the National Minimum Wage for Agriculture the position was that in a number of counties where the Forestry Commission were operating, special Orders were made for forestry workers. The orders usually prescribed a rate which was a few shillings above the minimum for agricultural

[1] This latest reduction to 48 hours represents, since 1939, a decline of 3½ hours weekly for the summer months and 1½ hours weekly for the winter months.

workers, and thus there was variation of wage rates between one county and another. Early in 1938 direct negotiations between the Transport and General Workers Union and the Forestry Commission established a standard rate of 38*s*. per week, which was 3*s*. per week above the then average agricultural rate. This standard rate was raised on 1st January 1940 by 4*s*. per week, an amount which more than maintained the early margin over the average agricultural wage. When the National Minimum Agricultural Wage was fixed at 48*s*. per week in July 1940, the Forestry Commission adopted this rate as a minimum, but paid increases of 2*s*. to 4*s*. per week to selected workers. When the National Minimum Agricultural Rate was increased to £3 per week, the Forestry Commission decided to adopt that rate as standard.

In November 1944 a National Industrial and Trades Council was set up between the Forestry Commission and the three unions catering for their employees. Under an agreement made in November 1944 and revised in July 1945 male adult workers were placed in three grades, according to their skill and the extent which they required supervision. In Grade I reliable men of outstanding skill who required a minimum of supervision received 5*s*. above the Agricultural minimum wage, while Grade 2 workers who were skilful above the average but required slightly more supervision received 2*s*. 6*d*. less than those in Grade 1. Grade 3 were ordinary labourers who, like the female and juvenile workers, received the appropriate Agricultural Minimum Wage. Drivers handling heavy caterpillar tractors received a commencing rate of 75*s*. (5*s*. above the then Agricultural Minimum Wage), which was to be raised in two steps of 5*s*. each at six-month intervals to 85*s*. During weeks in which they did any driving, lorry drivers were paid at the rate agreed by the Road Haulage Central Wages Board. Otherwise their wages and conditions were based on those relating to Grade 2 Forest Workers.

Piece-work rates, where mutually agreed, were fixed so that workers of average ability could earn in the ordinary hours at least 25 per cent. above the time rates. It is not possible to state precisely the scale of these piece-work rates because these varied for different localities and depended on the type of work done and also on local conditions. Planting, weeding, draining, and timber felling are operations commonly done on piece-work. Piece-workers working overtime were paid in addition the appropriate overtime increases on their time rates. From Monday to Friday, overtime was fixed at 1¼ times for the first 2 hours, and 1½ times thereafter, the ordinary rate, and at 1½ and 2 times for Saturday afternoons and Sundays, respectively, although for week-end fire patrols the rate was only 1½ times—a rate which also applied to this work on statutory and proclaimed holidays. (Otherwise the rates on these holidays would have to be twice the ordinary rate, and time off in lieu would have to be given.) Holidays with pay to the extent of 6 days per annum, plus 5 days public or statutory holidays, or the holidays prescribed by the Agricultural Wages Board's Orders if they are greater, were to be allowed. The normal working week was 5½ days.

There appears to have been little organization amongst the workers in the home grown timber trade previous to August 1941, and there was no established wages negotiating machinery, although it has been stated that the wages were very

low and the conditions poor. However, from August 1941 a National Joint Industrial Council for the home grown timber trade was set up. The objects of this council were to secure joint action between the employers and employees on points of common interest 'with a view to the general improvement of conditions in the industry and to promote the best interests of all engaged therein'. The following objects were specified:

(*a*) The consideration of measures for securing the loyal adoption of the decisions and conclusions of the Council by all Employers and Employees in the industry.
(*b*) The regular consideration of wages, hours and working conditions in the industry, with a view to establishing and maintaining such conditions as shall be equitable between the Employers and Employees, provided always that the various areas and sections of the industry shall, if required, be considered separately by the Council, whose decision shall be final.
(*c*) The prevention of any strike or lock-out from taking place in any locality until the matter has been considered by the Council.
(*d*) The consideration of matters relating to the health of those engaged in the industry.

Since the original awards, changes have been made in the terms. The more important details relating to men's wages are set out in Table 4. Women's wages were generally in line with men's wages and, indeed, where a woman replaced a man and performed all the work normally carried out by a man, she was to be paid at the appropriate male rate. Since August 1943 the increases represent for (*a*) sawyers, machinists, and skilled fellers, $4\frac{1}{2}d.$; (*b*) all other adult male workers, including crane drivers, $4d.$; and (*c*) women and youths, $2\frac{1}{2}d.$ per hour.

Among the conclusions which may be drawn from this general study of changing rates is the need for increasing or maintaining the efficient management and organization of labour. This normally implies a greater output per man, which in some industries can be achieved by associating more capital with each man employed, frequently in some form of mechanization, or by concentrating on a more valuable product. This raises the questions of the scope for more mechanization, at least in some forestry operations, and also how far some less essential operations may have to be eliminated. One can infer that the higher rates of wages have already rendered obsolete certain practices or operations current in the nineteenth century.

Under free competition the price of timber, which as a product enters so largely into international trade, will not be wholly, or possibly even largely, determined by the home costs of production. Although it may be reasonable to expect some increase in the price of timber in conformity with that of wages in Britain, it may still be necessary to vary such things as the amount of pruning work and planting distances, always within the limits of sound silviculture, if private forestry is to continue to pay wages at a level which will attract the most suitable men from rural areas. This leads to the observation that in British forestry the scale of financial outgoings—on one of the most important items of cost, namely wages—in the past has been largely set by the conditions and policy relating to the larger employing industry of agriculture.

Recent evidence, however, suggests that the element of grading and consequent

incentive in the rates for forest workers, and the possibility of having a link with the more responsible posts in the Forestry Commission, have attracted a large number of first-class men for training who would otherwise have been attracted to other callings.

On the one hand, judged by the statistics and evidence of those interviewing candidates for the post-war training schemes; forestry has been attracting a very good type of trainee and in relatively large numbers, while, on the other hand, the agricultural scheme has not yet met with the numerical response expected. At first sight this result is rather surprising and may be attributed to the better opportunities for eventual promotion, because forestry does not offer as many or as good opportunities of extra wages to the general run of workers as agriculture does. This is further evidence that the rate of wages is only one factor, and not the most important, in the attractiveness or otherwise of an occupation. The wages arrangements, however, for forest workers will not be without a considerable influence on the rates and conditions of service for workers on private estates. One outstanding effect of the above agreements for the home-grown timber trade will probably be to bring wage levels in rural industries into closer relationship with essentially urban industries than they have been in the past. Already, as the comparison of the wage rates of different occupations makes clear, the upward war-time movement of the rates for agriculture, and therefore for forestry, has been at a relatively greater pace than for industry in general.

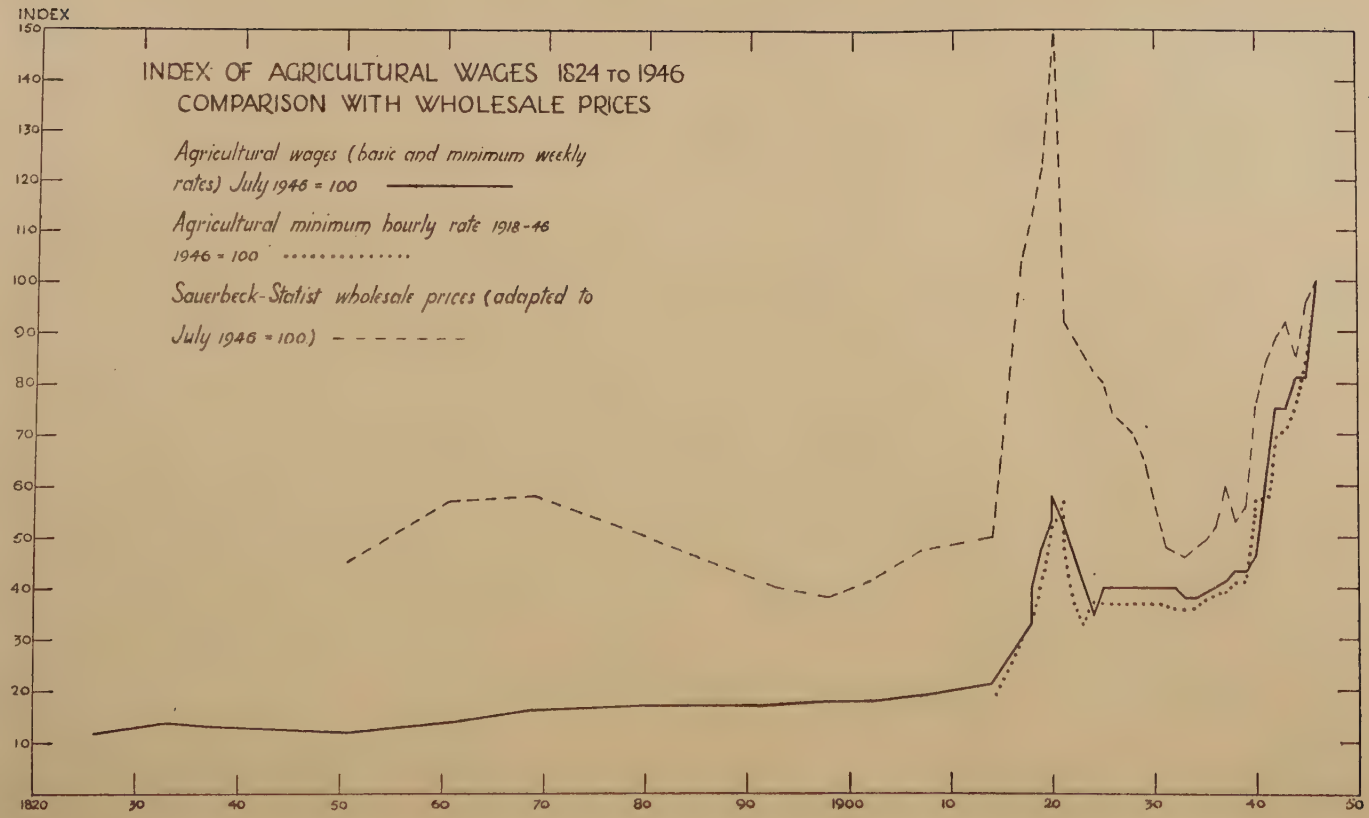

INDEX
INDEX OF AGRICULTURAL WAGES 1824 TO 1946
COMPARISON WITH WHOLESALE PRICES
Agricultural wages (basic and minimum weekly rates) July 1946 = 100
Agricultural minimum hourly rate 1918-46 1946 = 100
Sauerbeck-Statist wholesale prices (adapted to July 1946 = 100)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1820
30
40
50
60
70
80
90
1900
10
20
30
40
50

TABLE 1. *Weekly Cash Wages of Agricultural Workers.*

Year	Div. 1 s. d.	Div. 2 s. d.	Div. 3 s. d.	Div. 4 s. d.	Div. 5 s. d.	Div. 6 s. d.	Div. 7 s. d.	Unweighted Average s. d.	Unweighted Average Index 1946 = 100	Sauerbeck-Statist Index[1]
1824	11 6	10 3	8 10	7 8	8 4	10 1	8 11	9 6	12	
1833	11 1	12 3	9 8	8 9	10 4	11 10	10 4	10 8	13	
1837	12 2	11 6	9 7	8 1	9 3	10 8	10 4	10 3	13	
1850–51	12 2	10 1	8 4	7 9	8 8	9 1	7 10	9 7	12	45
1860–61	12 3	12 6	10 4	9 7	10 7	11 10	11 1	11 7	14	57
1867–71	15 1	13 4	11 4	10 6	11 7	11 8	11 0	12 5	16	58
1879–81	16 2	14 5	13 4	12 4	13 0	13 10	12 6	13 9	17	50
1892–93	16 5	15 2	12 6	11 8	12 4	12 10	11 10	13 4	17	40
1898	16 10	16 2	13 10	12 7	13 0	14 10	11 11	14 5	18	38
1902	18 0	16 9	13 10	13 3	13 7	15 4	12 11	14 10	18	41
1907	17 3	16 3	14 8	13 8	13 11	15 9	12 10	14 11	19	47
1914	22 3	16 7	15 3	14 3	15 7	17 4	15 10	16 9	21	50
1917	28 10	25 10	21 10	19 7	22 2	23 0	23 11	23 4	30	104
Sept. 1918	31 10	28 7	24 5	24 0	26 0	26 11	25 10	26 10	33	113
Winter 1918	34 4	32 5	31 6	30 5	30 5	32 2	30 8	31 8	40	
May 1919	39 6	38 2	37 1	36 5	36 9	38 8	37 2	37 6	47	122
April 1920	45 3	42 6	42 2	42 0	42 1	43 0	42 2	42 9	53	149
Aug. 1920	49 3	46 6	46 2	46 0	46 1	47 0	46 2	46 9	58	
Sept. 1921	43 5	42 1	42 0	42 0	42 0	42 3	43 4	42 5	53	92
1924	31 10	27 10	27 9	28 6	26 7	27 3	25 8	27 11	35	82
Sept. 1925	34 8	33 9	30 8	31 1	30 3	31 5	29 5	31 7	40	80
„ 1926	34 8	33 7	30 10	31 1	30 5	31 8	30 0	31 9	40	74
„ 1927	34 5	33 7	30 10	31 1	30 5	31 9	30 0	31 9	40	72
„ 1928	34 5	33 7	30 10	31 1	30 5	31 9	30 0	31 9	40	70
„ 1929	34 5	33 7	30 10	31 1	30 5	31 9	30 0	31 9	40	67
„ 1930	34 7	33 7	30 10	31 3	30 5	31 9	30 0	31 9	40	57
„ 1931	34 11	32 11	30 6	31 3	30 5	31 9	29 4	31 7	40	48
Jan. 1932	33 10	32 11	30 5	31 4	30 5	31 7	29 4	31 5	39	47
„ 1933	32 4	31 7	29 9	30 7	30 1	31 0	29 4	30 8	38	46
„ 1934	31 6	31 7	29 9	30 6	30 1	31 0	29 6	30 7	38	48
„ 1935	31 11	32 7	30 5	31 7	30 6	32 2	30 6	31 5	39	49
„ 1936	32 7	32 11	31 1	31 10	31 8	32 2	31 2	31 11	40	52
„ 1937	33 7	33 7	31 5	32 0	32 4	32 9	32 2	32 7	41	60
„ 1938	34 10	35 0	33 6	33 8	34 3	33 11	33 2	34 1	43	53
„ 1939	35 4	35 6	34 0	34 1	34 9	34 6	34 4	34 8	43	56
„ 1940[2]	37 11	38 4	36 6	36 1	37 4	36 4	36 4	37 0	46	76
„ 1941[3]	48 3	48 8	48 0	48 0	48 0	48 1	48 0	48 2	60	84
„ 1942	60 0	60 0	60 0	60 0	60 0	60 0	60 0	60 0	75	89
„ 1943[4]	60 0	60 0	60 0	60 0	60 0	60 0	60 0	60 0	75	92
„ 1944	65 0	65 0	65 0	65 0	65 0	65 0	65 0	65 0	81	85
„ 1945[5]	65 0	65 0	65 0	65 0	65 0	65 0	65 0	65 0	81	96
„ 1946[6]	70 0	70 0	70 0	70 0	70 0	70 0	70 0	70 0	87	100
1946[7]	80 0	80 0	80 0	80 0	80 0	80 0	80 0	80 0	100	

[1] Sauerbeck-*Statist* Index relates to average wholesale prices of 45 commodities and is here adapted to a new base 1946 (Jan. to July = 100). The index numbers relate to calendar years.

[2] National Minimum Wage was fixed at 48*s.* as from June 1940.

[3] „ „ „ „ 60*s.* „ end of Dec. 1941.

[4] „ „ „ „ 65*s.* „ „ Dec. 1943.

[5] „ „ „ „ 70*s.* „ „ March 1945.

[6] „ „ „ „ 80*s.* „ „ July 1946.

[7] Relates to July 1946 onwards.

TABLE 2. *Average rate per Hour for Agricultural Minimum Wages, 1918–46.*

Year	Average No. of Hours	Rate per Hour	Index 1946=100	Year	Average No. of Hours	Rate per Hour	Index 1946=100
1914	58	3·6*d.*	18	1931	51⅛	7·4*d.*	37
1918	52	6·9	34	1932	52¼	7·2	36
1919	52	8·4	42	1933	52¼	7·1	36
1920	49⅛	10·4	52	1934	51½	7·2	36
1921 July	49⅛	11·4	57	1935	51½	7·5	39
1921 Sept.	49⅛	10·4	52	1936	51¾	7·7	39
1921 Oct.	50	9·6	48	1937	51½	7·8	39
1922 Sept.	51	7·3	37	1938	51½	8·1	41
1923 „	50¾	6·6	33	1939	51½	8·1	41
1924 „	50¾	7·4	37	1940	51½	11·4	57
1925 „	51	7·4	37	1941	50¾	11·7	58
1926 „	51	7·4	37	1942	51	14·1	70
1927 „	51½	7·3	37	1943	50⅝	14·2	71
1928 „	51½	7·3	37	1944	50⅝	15·3	76
1929 „	51⅜	7·4	37	1945	50⅞	16·6	83
1930 „	51½	7·4	37	1946	48	20·0	100

TABLE 3.[1] *Changes in Wage Rates in Certain Occupations (as percentage of August 1939).*

	1940 Apr.	1941 Apr.	1942 Apr.	1943 Mar.	1944 Mar.	1945 Mar.	1946 Jan.	1946 Apr.	1946 July	1946 Sept.
Bricklayers	105·5	112·5	118	118	123	128	153	153	153	153
„ labourers	107·2	117	123	123	128	136	163	163	163	163
Printers and Compositors	—	107	113	115	125	125	137	137	137	137
Dock labourers	107·6	115	115	115	123	123	145	145	145	145
Engineers: Fitters	107·5	113	120	129	129	135	141	150	150	150
„ labourers	109·7	117	126	138	138	146	154	166	166	166
Shipbuilders	113	119	129	140	140	147	156	167	167	167
Railwaymen	106	110	118	127	134	141	156	156	156	156
Cotton	113	132·5	135	147	156	156	172	182	193	193
Wool	119·3	119	129	138	146	146	158	158	158	158
Local Authorities	106·2	114	121	126	132	140	154	155	156	156
Trams	106·6	118	124	124	131	139	139	150	151	151
Lorry drivers	107	113	119	122	126	130	135	144	144	144
Boots	110·5	121	121	121	132	137	163	163	163	163
Confectionery	106·9	117	135	141	149	159	169	169	169	169
Tailoring	110	123	123	137	137	153	153	153	183	183
Shirts	110	123	123	137	137	153	153	153	183	183
Tobacco	—	121	123	122	128	130	131	131	131	132
Coal[2]	112·7	123	139	163	176	195	203	203	200	200
Agriculture[3]	107·6	139	173	173	187	201	201	201	230	230
Weighted average	—	118	126·5	135	141	148	160	164	166	166[4]
Cost of living Index				128	129	130	131	131	132	131[4]

[1] Prof. A. L. Bowley, *Wages and Earnings and Hours of Work.* London and Cambridge Economics Service's Reports on Current Economic Conditions, Royal Economic Society.

[2] Average earnings per man-shift. Provisional from March 1945.

[3] Until National Minimum Wage introduced June 1940, average of county minima for ordinary labourers, weighted by the presumed relative importance of the counties.

[4] Provisional.

TABLE 4. *Wages Agreements of the National Joint Industrial Council for Home-Grown Timber Trades (Male Workers).*

A. FOREST WORKERS AND HAULIERS (WEEKLY MINIMUM)

	Oct. 1941 s. d.	*Aug. 1943* s. d.	*June 1944* s. d.	*Oct. 1945* s. d.	*July*[1] *1946* s. d.
Adults over 21	60 0	67 10	71 9	77 7½	83 6
Skilled fellers	75 0	82 10	86 9	92 7½	100 5½
Mechanical drivers in the woods (48 hrs.)	67 6	75 4	79 4	85 4	91 4
Loaders working only in the woods	60 0	67 10	71 9	77 7½	83 6
Overtime	1¼ times ordinary rate for first 10 hours over 47, with a limit of 2 hours per day, thereafter 1½ times ordinary rate.				
Overtime (week-ends)	Twice ordinary rate from Saturday 4 p.m. to Monday 5 a.m.				
Road drivers and mates	Not less than wages laid down by the Central Road Haulage Wages Board in the document R.H. (8).[2]				
Overtime (road drivers and mates)	1⅛ times ordinary rate;[3]		1¼ times ordinary rate.[4]		
Youth rates[5]					
Age 15 years	—	26 5	28 4½	32 3½	36 2½
Age 16 „	—	31 5	33 4½	37 3½	41 2½
Age 17 „	30 0	33 11	35 10½	39 9½	43 8½
Age 18 „	37 6	43 4½	45 4	49 3	53 2
Age 19 „	45 0	50 10½	52 10	56 9	60 8
Age 20 „	52 6	58 4½	60 4	64 3	68 2

B. SAWMILL WORKERS[6]

Mills were classified A, B, and C to correspond with the 'Port-City', 'Town', and 'Country' Mills respectively of the Timber Control classification. The rates for the 'Country' Mills (Category C), which in 1941 were about 10 to 15 per cent. less than for Category A Mills, were as follows, while rates for youths were identical with those for Forest Workers and Hauliers of similar ages:

	Per hour (Country Mills)				
	s. d.	s. d.	s. d.	s. d.	s. d.
Skilled sawyers	1 7	1 9	1 10	1 11½	2 1½
Rough sawyers[7]	1 4½	1 6½	1 7½	1 9	1 11
Mill labourers	1 3½	1 5½	1 6½	1 8	1 9½
Crane drivers	—	1 6½	1 7½	1 9	1 10½

[1] These increases represented *2d.* per hour for sawyers, machinists and skilled fellers and 1½*d.* and 1*d.* per hour for adult male workers and youths respectively over October 1945 rate.

[2] Document R.H. (8) is too complicated to summarize briefly since wages were fixed according to the age of the worker, the carrying capacity of the vehicle, and the grade of the district. Between August 1943 and July 1946 in addition to alterations in the overtime conditions, transport workers have had increases amounting to 24*s.* per week.

[3] For first 8 hours over 48, and 1½ times over 56 hours during week-days and 2 times for Sunday.

[4] For first 8 hours over 48, and 1½ times over 56 hours during week-days and 2 times for Sundays.

[5] An extra 5*s.* per week was paid where youths operated machines.

[6] The same general principles as for Forestry Workers and Hauliers governed the conditions for piece-work rates, overtime, and youths who operated machines. The rates were qualified in so far as they related to machinists, so that in no case could the rate exceed the district rate, if any, fixed by the Timber Trade Federation (Sawmilling Section) agreement. The agreement related to firms which in normal times were mainly engaged in the conversion of imported timber.

[7] Cutting pit-wood, fencing, firewood, slabs and offcuts, tops and all timber 7 in. and under *q.* girth *t.u.b.*

PRIVATE FOREST ESTATES IN THE BRITISH ZONE OF AUSTRIA (1946)

By SIR HAROLD GLOVER

RECENTLY I was fortunate to spend a year in the forests of Styria and Carinthia. I have given a general account of these forests in a recent number of the *Empire Forestry Review*, but think that a more detailed note on the privately owned forest estates may be of interest, as such forests form a very high proportion of the whole.

The country is very beautiful. The high hills are covered with forest up to an altitude of about 6,000 feet, which then gives way to alpine pastures, rocks, and majestic peaks. The main valleys are open, with grassy meadows and alder beds in their bottoms and with coniferous forests on the cooler aspects. There are some arable fields and much grassland on the warmer slopes, which are dotted with substantial farm-houses and barns, largely built of wood, and with woods. The lakes of Carinthia rival those of Kashmir.

Approximately one-half of the British zone is under forest, with the result that timber and forest products dominate the economy of the country, particularly now when iron foundries are stagnant and factories are at a standstill.

Only 5 per cent. of the forest area of Carinthia and 12 per cent. of Styria are owned by the State, and some 8 per cent. by the Church and corporate bodies. The balance is privately owned, there being over 2½ million acres of private forest in the British zone. Half of this area belongs to big landlords who manage their woods for the production of commercial timber; half belongs to farmers who use the woods primarily to supply the needs of their farms and as grazing-grounds. In every farm there are patches of carefully preserved forest which the farmer prizes as much as his pasture and fields, with the result that forestry and agriculture are knit closely into the economic life of the country.

The forests consist mainly of spruce, larch, Scots pine, and silver fir, occasional *Pinus cembra* and *austriaca* and at high altitudes dwarf pine, *Pinus montana*, together with a small proportion of broadleaved trees, oak, beech, birch, hornbeam, ash, maples, poplar, willow, alder, and other species. At the lower levels, as in eastern Styria, broad-leaved trees form a considerable proportion of the crop and there is no doubt that originally they covered large areas and have been ousted by conifers, planted because of their superior commercial value.

In ancient times iron ore, of which there are large deposits, was smelted with wood charcoal as there was no hard coal. Vast tracts of forest were devastated, erosion started and was followed by such frequent and disastrous floods that a law was passed in 1853 whereby no trees could be felled over more than half an acre without previous permission from the Provincial Government, and all areas so felled had to be restocked within 5 years. It is due to this law that Austria to-day possesses its present fine heritage of forests of more than national importance.

Nearly a hundred years ago spruce seed was sown broadcast on the snow, and to this the present woods largely owe their origin.

In ancient times the country was divided into feudal estates where each count, baron, or squire lived in his castle, surrounded by his retainers and tenant farmers. Forests then had little value except for sport and the limited domestic and agricultural requirements of isolated communities. In order to increase the numbers of their supporters the landlords gave out land on favourable terms to immigrants, with permission to graze animals and cut timber in the forests. Gradually, as time went on, these concessions became rights of user which eventually were acknowledged and fixed by a Government Commission appointed to inquire into peasants' grievances. Sometimes the landlords retained only the more remote forests in the hills, which were most suited to sport, and surrendered the woods near the farm-houses; sometimes a large area of forest was retained over which the peasants were granted extensive rights to timber and grazing. The result to-day is that the commercial forests lie at a distance from centres of consumption, and transport is lengthy, difficult, and expensive, while the more accessible blocks of forest are split up into many small units owned by individual peasants and farmers.

It will be convenient to distinguish between the larger estates managed for the commercial production of timber and those belonging to farmers, generally of much less than 125 acres in extent, managed firstly for local requirements and only secondly for timber for sale.

THE LARGER FOREST ESTATES.

These vary in size from a few hundred acres to, in one case, 70,000 acres in extent and lie mainly in steep country. Nearly all are managed according to approved working plans which up to the war were revised every 10 years.

The topmost belt of forest, about 5 per cent. of the whole, is preserved as a protection from avalanches and erosion, and only over-mature trees are felled there. The remainder is devoted to the maximum production of timber for the market, the silvicultural system and rotation being left to the choice of the owner, who is obliged by law to maintain the forest as such and to replant all felled areas within 5 years.

The silvicultural system. Most of the forests are managed under the clear felling system followed by the planting of spruce or Scots pine. Where larch trees are present they are retained as seed bearers in order that the young woods shall contain as many of these valuable young trees as is possible.

Larch is sometimes planted, but the transplants do not grow so well as natural seedlings.

Sometimes, as in the Schwarzenberg forests, the larch seed-bearers are left to grow for a second rotation, when they produce timber of the highest quality.

After the fellings are completed the branch wood is piled in long strips along the lines of greatest slope and the area is left for 3 years in order to allow the pine weevil, which lives in the stumps of freshly felled trees and attacks young plants, time to perish.

Four-year-old spruce transplants are put out in the spring, as soon as the snow melts, with Scots pine replacing spruce on hot aspects. Gaps are replanted at once.

Extensive clear fellings are universally condemned on account of the serious decline in soil fertility which follows on the complete removal of the over-wood. This results in very slow growth of the young plantations and frequently the spruce transplants are no more than knee high after 10 years. Sometimes at high altitudes it takes from 15 to 20 years before the side branches of the saplings meet, after which height growth is much more rapid.

The arguments in favour of clear fellings are the cheapness of extraction and the failure of natural regeneration at high elevations, where the spruce seeds irregularly at long intervals. Many forest officers are in favour of clear fellings, provided the first opening is definitely limited to 2 or 3 acres, so as not to expose the soil unduly to atmospheric influences. The areas are then extended by felling trees along strips against the direction of the prevailing wind. Where light seeding fellings are made in these strips, regeneration is often obtained naturally, where the climatic conditions are not very adverse.

During the last 25 years a compromise between extensive clear fellings and more conservative methods has been practised, whereby vertical strips, in breadth equal to from one to one and a half times the height of the trees, are cut through the forest and planted with spruce, larch trees being retained as seed bearers. The strips are broadened by clear fellings on the side sheltered from the prevailing wind, and where the ground is not very steep seeding fellings are sometimes substituted for clear fellings in the adjacent forest.

This vertical strip system has many advocates, as it is claimed that it combines the advantages of cheap extraction with protection of the soil, but many foresters do not favour the system. The results sometimes have been very good indeed, but success is by no means uniform.

Wind does much damage, and occasionally, as happened in February 1946, very extensive areas of forest are blown down. High winds usually come from the west, but in the valleys the wind is apt to be deflected and local knowledge of the vagaries of storms is essential in order that all fellings shall take place against the prevailing direction of the wind.

Some owners who manage their forests on commercial lines endeavour to get as much natural regeneration as is practicable. Advantage is taken of the tendency of conifers to invade broad-leaved forest, particularly alder, which grows abundantly in moist localities, and beech which not only greatly improves the quality of the soil but makes regeneration easy. Generally speaking the correct principles of forestry are well understood, and most foresters are in favour of a much wider adoption of methods of natural regeneration and the creation of mixed woods with a proportion of broad-leaved trees, but they have been hampered by lack of funds and high taxation, which have resulted in the abandoning of the best silvicultural practice in favour of cheap methods of exploitation.

Thinnings. The woods are frequently left unthinned until they mature. The arguments against thinnings are the high costs of extraction and the damage done

to the bark of standing trees when timber is dragged down steep slopes. This is largely due to an inadequate network of extraction roads, as where communications are good and the forests are so situated as to make thinnings profitable they are carried out and are followed by improvement in the growth of the crop.

In some estates, at the first thinnings, vertical lines are cut, along which timber is extracted, the intention being that at subsequent thinnings all timber shall be extracted along these lines.

Transport. The country is mountainous and much of it is remote, so that road construction and maintenance are expensive. The value of timber depends on its accessibility, and for many years past the near-lying forests have been heavily exploited. During the war the Germans ordered the yield to be increased, and the most accessible forests were felled, so that to-day most of the mature timber lies far from the motor-roads and railways. Trees are felled in the spring, are barked and are allowed to dry during the summer, and logs are slid down the hill-sides and shoots in the early snow. In the winter timber is carried on sledges, either direct to railway stations and saw-mills or to depots on motor-roads. Earth and wooden slides are used extensively, while water transport is highly developed in the higher reaches of the rivers.

Wire ropeways are erected where roads are lacking, particularly on the higher and steeper hills, and are very efficient. Some serve to transport the whole of the timber of large valleys and some, generally erected by Italian engineers, have little to fear from comparison with the most advanced American methods. A considerable capital has been invested in these ropeways, and in order to use them to the greatest financial advantage, by carrying as much timber as possible, whole forests have been sacrificed.

The increasing use of tractors and motor transport has made it necessary to overhaul and modernize the network of forest roads with a view to rendering accessible the unexploited reserves of mature timber which lie in the recesses of the hills. These new roads will not by any means all be motor-roads, as sledge roads are cheaper and easier to build and are very efficient. The Austrian foresters have made the plans but require money to carry them out.

Saw-mills. There is abundant water power in the streams which drain every valley, and on every small stream are water-driven saw-mills of simple design, worked by the owner with or without assistance. In addition there are numerous saw-mills driven by steam or hydro-electric power, some of them of modern design and with up-to-date machinery. Altogether there is ample machinery to convert at least twice as much as the sustained annual yield of the forests, and the saw-milling industry is over-capitalized.

There is one modern pulp-board plant which uses the refuse from mills for 50 miles around: a second improved plant was destroyed by bombs just before the war ended. There are also specialized barrel and other wood-working machines. Many of the forest-proprietors own saw-mills, and both saw-millers and paper millers own extensive areas of forest.

Pulp and paper mills. These vary from primitive water-driven mills, which produce mechanical pulp, to huge modern mills able to process many thousands

of tons annually. Like the saw-mills they are capable of treating far more timber than the forests can produce and are accustomed to import timber from beyond the British zone.

Working plans. The forests of all the larger estates are managed under working plans which are compiled with meticulous care and accuracy. There are firms of practising foresters who undertake this work, but some of the larger estates prepare their own working plans.

The choice of the rotation depends on the conservatism of the owner, on the distribution and proportion of the age classes, and on the rate of the annual increment, which varies according to the factors of the locality. The lowest rotation is 80 years; generally it lies between 100 and 120 years, but in very unfavourable situations it may be longer. Each working plan is approved by the Provincial Forest Administration, as it has to provide an adequate planting scheme in accordance with the 1853 Forest Law.

The Yield. Careful assessments of the growing stock and the rate of increment are made by the working-plan officers.

The annual yield varies according to the factors of the locality, but is about 40 cubic feet solid per acre. In Carinthia fellings are in excess owing to the temptation of favourable markets in Italy. In both provinces the yield was exceeded during the war, as the Germans ordered that the fellings should be as heavy as could be carried out with the labour available and that the most accessible forests should be felled first.

Finance. It is not easy to ascertain the correct financial position of the forests. Some of the larger estates are still making a small profit, but most are finding it difficult to make ends meet. Some, for example the Schwarzenberg estate, have been managed so conservatively in the past that they still work at a profit: others took advantage of high prices after World War I to fell heavily and made inroads into their forest capital, and some forests are now actually worked at a loss. This is largely due to direct taxation and to the social contributions which raise the cost of labour, combined with the control which Government exercises over timber sale prices. The present prices are low, only about one-quarter of what are offered for export, and it is unlikely that prices will remain at such uneconomic levels. I formed the opinion that control was acting adversely on the finances of the producer, and that prices must be raised in accordance with world prices if forestry is to be made to pay and necessary expenditure is to be incurred on development, particularly on extraction roads. The Central Austrian Forest Administration was in full agreement with these opinions, but as the whole matter of forest finance is linked with that of the Austrian State, which is terrified of inflation, it is unlikely that orders will be passed until a solution has been found for the more troublesome question of national finance.

THE FARMERS' FORESTS.

Much of the land lies at too high an elevation to grow remunerative arable crops; a great deal of it is pasture or is cultivated for hay, and the balance is better suited to the growth of trees. Every farmer either possesses or would like to own

a forest. This does not mean that the forest is reserved only for the growth of trees, as it still has to serve as a grazing ground for the cattle and for the provision of litter for the stalls. This last demand is insistent, and not only are pine needles and fallen leaves collected but green twigs of all felled trees are chopped up and used for litter. Sawdust is bought at the saw-mills for this purpose. In former years conifers were lopped for litter, a practice which is now forbidden as it causes the timber to rot: broad-leaved trees and isolated spruce trees are still lopped.

Farm implements are made chiefly of wood, while wooden sledges and carts are used on the steep roads. The houses and barns are built largely of wood, and until recently were usually roofed with wooden shingles, which are rapidly giving place to tiles or asbestos slates.

Firewood is burnt in stoves and kitchen ranges, and surrounding every house are stacks of wood fuel, of which large quantities are consumed during the severe winters. During the past winter firewood was burnt by the British troops and was substituted for the soft coal usually burnt in the towns. In ordinary times timber is more valuable than firewood, and some villages are accustomed to buy coal in order to be able to save their timber for sale.

The farmer never sells his forest save when necessity compels, or when he wants funds for his daughter's marriage or to pay taxes. Sometimes, however, he succumbs to the temptation to sell timber before it is mature, to the persistent agents of the numerous paper-mills or saw-mills who solicit his custom.

Co-operative Forest Societies. The farmers' forests rarely yield one-half as much timber per acre as do the forests of big estates or the State, largely because they are misused and mismanaged, but particularly because large stretches of woodland are parcelled out amongst numerous individual proprietors, none of whom owns more than a few acres of forest. This subdivision makes economic working extremely difficult, particularly as there are no roads which serve the whole forest.

The formation of co-operative forest societies is advocated by Government, and has made considerable headway in Styria where special rules have been in force since 1909 and are preferred locally to those introduced by the Germans in 1943.

I inspected the forests of some go-ahead societies, where good management has already been followed by manifest improvement in the condition of the forests. Recently the co-operative movement received a check, as the villagers feared that under the German régime consolidation of the forest estates might be followed by confiscation.

One co-operative society's forest which I visited was particularly interesting, as British prisoners of war had been employed to build a road which enabled neighbouring owners to extract timber from forests which previously had been inaccessible. These British prisoners of war are well remembered for their useful work and good behaviour.

Nurseries. The larger estates maintain their own nurseries. The State also has nurseries from which it distributes seedlings at cheap rates to farmers and land

holders who need plants. This undoubtedly has greatly helped landowners, particularly the farmers, to replant the areas felled over. Seed at present is virtually unobtainable as Austrian foresters had grown accustomed to buy seed in Innsbruck, and particularly in Wiener Neustadt, where the seed-drying sheds and plant have been completely destroyed by bombing. There is plenty of seed on the trees this year and special efforts will be made to collect and dry as much as possible.

Nurseries are located at convenient centres where there are roads, and a water supply which usually is piped. A sufficiently large area is set aside to permit of the nursery beds being fallowed and planted with legumes in order to maintain fertility, and a nursery is used for about 20 years before it wears out.

The raised nursery beds are one metre in breadth: the seedlings remain in the beds for 2 years and are then pricked out in rows, usually for 2 years. When growth has been more rapid than usual they are planted out at 3 years (2+1). The transplants are generally much smaller than those used in England. Very efficient planting boards are simple to use and greatly decrease the cost of pricking out the plants.

Plantations. Four-year-old plants (2+2) are put out into the forest in the spring as soon as the snow melts, the greatest care being taken to keep the roots moist when the plants are taken from the nursery beds, by packing them in wet moss in which they remain during transport to the forest, where they are heeled in until they are planted out.

At all times great care is taken never to allow the roots to dry. About 75 per cent. of the transplants are spruce.

Organization and Control. Large estates employ trained forest officers of great skill and experience, who often are also fully qualified agriculturists and manage the whole demesne. Where, as usually happens, the working plans have been approved by Government they are left to conduct their own affairs with a minimum of interference. The estate forest officers have been trained at the same institutions as the State forest officers and they get on well together.

All estate forest officers, foresters, and watchers are expected to be interested in the protection of game, as the pursuit of game is still a favourite occupation not only of the aristocracy but of the rich industrialists, and shooting rentals are valuable assets.

Most small estates engage a forester, or at least a gamekeeper, who is quite able to carry out the routine duties of a forester.

Farmers rarely employ a trained forester but are by no means ignorant of forestry, as Government encourages them by providing special courses for landowners at the Provincial Forest Schools.

During the war the quantities of timber to be felled were controlled by Government. Every owner was allotted his quota, and at the same time prices were controlled at rates which were advantageous to users in Germany. This control still operates, but the methods by which it is exercised have been changed. Incidentally we took advantage of this control to allot quotas of firewood to each considerable landowner or group of forest proprietors when last winter it became

Fig. 1. Forests of the Hollenburg estate in the Carinthian Alps

PLATE II

Fig. 2. Typical spruce forest of the Hespa demesne

Fig. 3. A typical plantation of Carinthia

PLATE III

FIG. 4. Ropeways are used to carry logs—Hespa Estate

FIG. 5. The farmhouses are largely built of wood

PLATE IV

imperative to make good with wood fuel the failure of the coal supplies in the larger towns, thereby saving the townspeople from freezing to death.

CONCLUSION.

The last year was full of interest. Not only did I gain an intimate knowledge of the way in which an advanced European nation manages its forest business, but I got to know the reactions of the people and forest owners to State control. I was privileged to help the Commander-in-Chief when he ordered that the British troops in Austria should safeguard their own fuel supply by felling timber themselves for use as fuel. Naturally the impact of a large occupying force on local economy was considerable, but in the end the Army secured ample supplies of fuel and provided considerable quantities of firewood for the use of the civil population of Vienna. In addition the organization of the civil supply of wood fuel to the large towns was interesting and useful, and contacts with the Army and the use of Army transport made this possible. Military Government officers were always helpful, and although they knew little about forestry they were very willing to learn.

Austria has every reason to appreciate the courtesy and kindness of all ranks of the Army and the efforts which the British element of the Control Commission, assisted by Military Government officers, have made to set Austria on its feet and to restore its shattered economy.

ON THE APPEARANCE OF THE BARK-BEETLE *IPS TYPOGRAPHUS* IN BRITAIN ON IMPORTED TIMBER WITH NOTES ON PREVENTIVE AND CONTROL MEASURES

By W. B. R. LAIDLAW

(*Forestry Commission*)

INTRODUCTORY.

THIS bark-beetle appeared in Britain in the summer of 1946 on Norway spruce logs imported from Germany. These logs started to arrive at Leith, Aberdeen, and certain English and Welsh ports in June of 1946 and have been arriving at intervals since then. The consignments consisted of Norway spruce and Scots pine, of which the Scots pine and a small proportion of the spruce were not barked. The beetle was taken chiefly on spruce and was readily found on all consignments examined, both barked (where bark fragments were left) and unbarked. It was also found in two instances on Scots pine logs. Spruce logs barked before shipment, but with patches of bark adhering, often contained colonies of up to 200–300 beetles.

The timber was allocated to saw-mills all over the country, including a number in or adjoining some of the largest coniferous woodland areas in Scotland. This and the fact that at the start the spruce logs, too, were coming over unbarked led to justifiable fears in forestry circles lest the beetle, hitherto unknown as a breeding species in Britain, should escape from these logs and become established in our native woodlands.

OTHER INSECTS FOUND ON THE IMPORTED LOGS.

During the examination of the consignments at the docks and in the mills, a number of other insects were taken on the spruce and pine. These were as follows:

On spruce	*I. typographus*	Numerous
	Hylastes palliatus	A fair number
Predatory on *Ips*	*Rhizophagus* sp.	A few
On pine	*I. typographus*	A few colonies
	I. sexdentatus	A few colonies
	Myelophilus piniperda	Numerous
Predatory on *Ips*	*Thanasimus formicarius*	One
	Rhizophagus sp.	Small numbers regularly
	Small Carabid sp.	A few
Parasitic on *Ips*	*Chalcididae*	A few in one instance

A small beetle predatory on *Hylastes palliatus* was also taken.

THE CHARACTERS OF THE GENUS *IPS* (4).

The chief distinguishing characters are: the head concealed from above by the domed prothorax, the front half and sides of the pronotum roughened by small

teeth and wrinkles, and the apex of the elytra excavated, with a varying number of teeth along the top outer margins of the excavation, according to species. Six species occur in Britain. In three of these, other teeth occur between the marginal ones and the elytral suture. These three are as follows:

1. *Ips suturalis* Gyll. Moray and Inverness. Rare.
2. *Ips erosus* Woll. Forest of Dean. Rare on pine.
3. *Ips laricis* F. 3½–4½ mm. Common south of Northumberland—on pine.

The other three species have only marginal teeth on the elytra:

4. *Ips sexdentatus* Boem. 6–7 mm. Forest of Dean and imported. Not common on pine.
5. *Ips typographus* L. 4½–5 mm. Imported only—not breeding in Britain. Spruce and pine.
6. *Ips acuminatus* Gyll. 2½–3½ mm. Scotland, North England. Common on pine.

Ips laricis replaces *Ips acuminatus* in the south and is distinguishable from that species by its cylindrical form, steep declivity at elytral apex, and well-marked rows of elytral punctures: *I. suturalis* and *I. erosus*, both rare species, are distinguished from *I. laricis*, which they resemble, by the declivity being elongate-oval, not roundly oval, in *I. suturalis*; and in the second tooth from the top being rectangular in *I. erosus*, not conical-pointed as in *I. laricis*. *I. sexdentatus* and *I. typographus* are larger species. As its name indicates, the former has six marginal elytral teeth, the latter has four (see Figs. 1–3).

The species appear to be pine feeders. *I. laricis* has been found rarely on larch. *I. typographus*, our present subject, while found on pine, favours Norway spruce.

THE SPECIES *IPS TYPOGRAPHUS*.

Description.

Length 4½–5 mm. Dark brown to blackish. Newly matured specimens are light yellowish. Pronotum roughened in front half. Elytral puncture rows distinct, outer margins of tibiae serrated. Elytral excavation margined with 4 teeth—the third from the top the largest. Whole beetle shining and distinctly hairy. Mature larva and pupa, about ¼ inch.

Life-history and habitat.

Two generations per year are reported for good years in the case of *I. typographus*. Beetles emerging in spring produce a brood which matures from mid-summer (June) onwards. The earliest of these may give rise to a second generation which matures before the autumn.

On material inspected in 1946, larvae and pupae preponderated in June, but by the end of July they were in a minority, most having reached the adult stage. According to Fisher (2) each mother lays up to 50 (sometimes 120) eggs. These hatch in 14 days, during May and June, and the beetles mature in July or early August, when they go into hibernation. Those maturing before the end of June may at once produce a second generation which matures in September. Periods

given are: egg 2 weeks; larva 2 weeks; pupa 3 weeks; adult $3\frac{1}{2}$–4 weeks. Total periods vary from 6 to 13 weeks, according to season and local conditions. In rare cases three generations have been noted.

FIG. 1. *Ips typographus*. Beetle (× 12).

FIG. 2. *Ips typographus*. Elytron showing teeth (× 24).

FIG. 3. *Ips sexdentatus*. Elytron showing teeth (× 15).

Like others of the genus the species is polygamous. The galleries are 2–5-armed, according to the number of females leaving the pairing chamber. In the material examined, 3-armed were found, but 2-armed were more common. (See Plates I and II.)

The mother galleries always run vertically up and down the stem and are thus not stellate in character. Each commonly has two ventilation holes. Constructed

wholly in the bark they prefer the thicker-barked portions of the stem and occur down to the butt in logs of 1-foot butt diameter and over. The larval galleries are rather short, widening rapidly. Exit and ventilation holes are 2 mm. in diameter. Mother galleries are 3–3½ mm. wide and about 5 inches long. Larval galleries average 1 inch long and ¼ inch wide at the pupal chamber.

Effects.

Authorities in Sweden state that attacked spruce trees show withering and wilting of the current growth in their upper crowns and leaders. The needles turn red or yellow, while the bark becomes detached and falls off. With trees injured in summer the needles do not turn brown, as with spring injury, but remain green.

Where several colonies invade one tree, more or less complete girdling takes place by destruction of the cambium. Wilting, dying of the crown, and death of the tree may result, according to the severity of the attack.

The beetle appears to be capable of attacking trees only slightly reduced in vigour, such as could easily occur through a temporary drought, spring frost, or other temporary set-back.

Economic Importance.

In Sweden it is regarded almost as a primary pest. All trees found to be attacked are immediately felled and stripped of their bark to destroy the young brood.

Compared with other bark-beetles and wood-boring insects it seems certain that *Ips typographus* is essentially a pathological species, but it occurs in earlier stages of sap-deficiency in its host than would attract other Scolytid beetles.

Control Methods.

In Britain when the beetle was first reported on imported spruce in the summer of 1946 the following precautionary measures were taken. A large number of consignments were inspected both at the docks and at the saw-mills. When it became obvious, as it soon did, that all spruce imported from Germany was practically certain to carry the beetle, all timber merchants receiving such spruce were contacted—personally where possible, otherwise by letter—and their co-operation was invited. The potential danger was explained. They were asked to bark all unbarked spruce and burn the bark immediately. Where the timber was due for almost immediate conversion they were asked to burn the slabwood bearing the bark.

In addition, where mills receiving this timber were situated in 'danger' areas—i.e. outside large towns or cities and near coniferous woods—the owners were asked to lay down trap-logs of green Norway spruce on or beside the imported logs to attract any escaping beetles, and to bark and burn any beetle-infested trap-logs six to eight weeks later. Where they were not able to do this the Forestry Commission arranged to procure and send trap-logs. In a few instances Sitka spruce was included to find out whether the beetle would attack such spruce. Timber merchants showed a gratifying keenness to co-operate.

The results of trap-log inspection up to date (October 1946) have been negative. No *Ips typographus* have been taken, and only in one case were any beetles found. These consisted of *Hylastes ater* and numbers of predatory *Rhizophagus*.

In Germany, subsequent to the discovery of the beetle in Britain, orders were passed for the barking of all spruce before shipment. If this is thoroughly carried out the importing of the beetle should be reduced to a minimum.

In Sweden, as noted above, staffs on State forests are instructed to keep a sharp look-out at all times for withering, browning, and dying off of upper crowns and leaders. All trees so affected are felled at once and the bark is stripped to destroy the young brood. Similarly, in Britain it is hoped that during the spring and summer a careful look-out will be kept for any signs of attack in native spruce woods so that similar action may be taken if necessary.

Bionomic Control.

This species being controlled primarily by food supply, predators and parasites cannot provide a solution: none the less, they are an additional weight on the right side. The following are beneficial: Birds—woodpeckers, especially the Greater and Lesser Spotted; tits, on loose and thin barked material; Insects: predatory beetles imported with the logs occur also in Britain. *Rhizophagus* spp. are generally common, and *Thanasimus formicarius* locally so. There are, in addition, a number of parasitic *Hymenoptera* of the Chalcid and Braconid groups. *Homalium pusillum* (Staphylinidae) is reported by Fisher (2) on the Continent as a predator. Escherich (1) quotes lists of enemies given by Kleine (1908–9), naming 10 predatory beetles and 6 parasitic *Hymenoptera*. Two more of the latter are given by Fuchs (1915).

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DESCRIPTION OF PLATES.

Plates I and II. *Ips typographus*. Bark galleries. Showing A, pairing chamber; B1, B2, B3, mother galleries: C, ventilation holes; D, larval galleries. Photographs by W. P. Thomson, by permission of H.M. Forestry Commission.

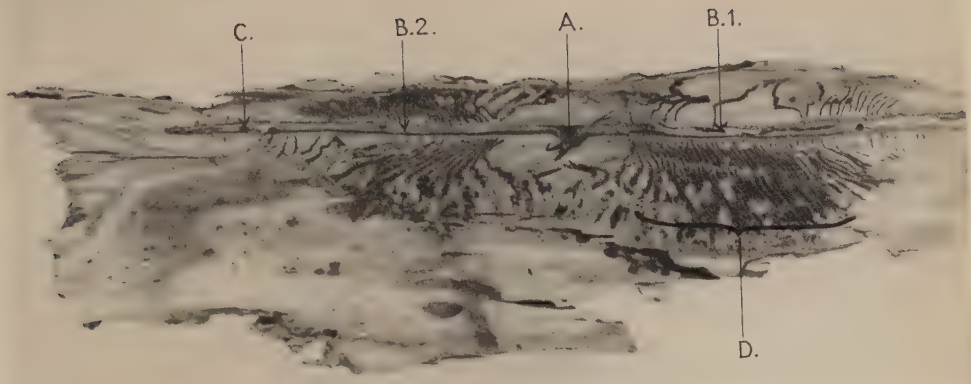

PLATE V

EFFECT OF SAP-STAIN ON THE TENSILE STRENGTH OF CORSICAN PINE SAPWOOD

(*Pinus nigra* var. *calabrica* Schneid.)

By C. B. PETTIFOR and W. P. K. FINDLAY

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INTRODUCTION.

THE effect of sap-stain on the strength of timber has been examined by numerous workers at different times but, as far as is known, none of these investigations included tensile strength among the properties tested.

The effect of sap-stain, produced by *Ceratostomella coerulea* and other similar fungi on the specific gravity, toughness, end-grain compressive strength, bending strength, stiffness, and hardness of Scots pine sapwood has already been investigated by this laboratory (1, 2). It was found that the fungi caused a marked drop in toughness, a very slight drop in specific gravity, stiffness, and hardness, and no appreciable change in bending or compressive strength. No tests were made at that time to determine the effects of sap-stain on the longitudinal tensile strength of the timber; such supplementary tests have now been made and form the subject of this report. Owing to the difficulty of obtaining adequate supplies of Scots pine sapwood, the tests were actually made on the sapwood of Corsican pine, but the two timbers are so similar that conclusions drawn from tests on the latter may be applied equally well to the former timber.

MATERIAL FOR TEST.

For these tests two logs of Corsican pine were obtained, each 15 feet long, and of diameters about 11 and 9 inches respectively; the diameter of the heartwood zone was 2–3 inches.

TEST-PIECES AND LAYOUTS.

The tensile test-piece developed as standard by the laboratory was used throughout; it is 12 inches long, $\frac{1}{4}$ inch thick, and 1 inch wide at the ends reduced to $\frac{1}{8}$ inch at the centre, the growth rings being parallel to the width.

It was decided to use, for these tests, three species of staining fungi with three periods of incubation for each; this, together with controls, sterilized and unsterilized, involved the preparation of eleven groups of matched test-pieces. In addition, a twelfth group was prepared for tests on unsterilized specimens before and after general infection. A number of 50–60 test-pieces per group was aimed at, as it was estimated that the average of this number should, with clear unstained specimens selected at random, reveal significant differences of the order of 5 per cent.

After preparation and testing, certain of the test-pieces had to be rejected for various defects, and the number remaining in each group ranged from 52 to 62.

The matching of the groups was effected as shown in Figs. 1(*a*) and (*b*). A line parallel to the axis was scribed down each log for alinement purposes, and bolts about 15 inches long, free from external knots and lettered consecutively *A* to *O* (*I* being omitted), were cut from the two logs. Corresponding faces of each bolt were divided into twelve approximately equal sectors, numbered clockwise 1 to 12 starting from the scribed line as shown in Fig. 1(*a*). On each of these sectors, blanks from which the test-pieces were subsequently cut were marked as shown in Fig. 1(*b*). These sets of blanks covered practically the same belt of growth rings in the sectors of any one bolt and were thus similar in their structural characteristics and, by inference, in their initial strength properties.

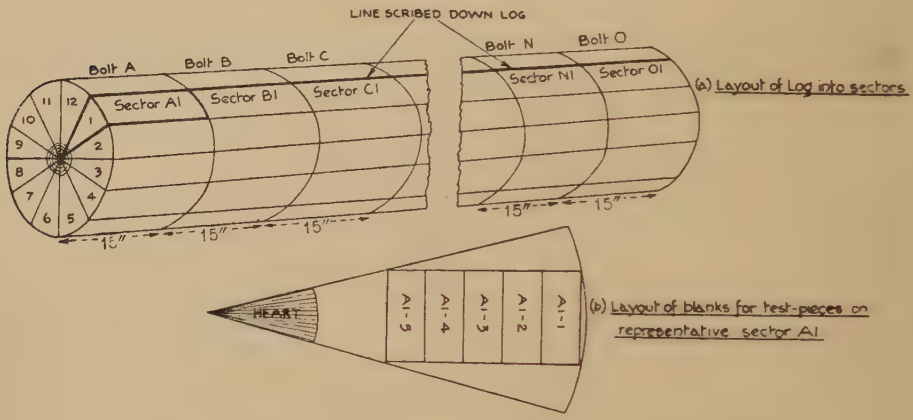

FIG. 1. Effect of sap-stain on the tensile strength of Corsican pine sapwood.

One sector from each bolt was assigned to each of the twelve groups referred to above; in order to minimize still further the effects of variation in the timber itself from the average values used in any comparisons, the number of the sector allotted to any one group was varied from bolt to bolt.

The selection for control and for treated test-pieces used to determine the effects of general infection was made at random from the sectors numbered 12 and from certain extra test-pieces obtained from other sectors.

After preparation the test-pieces were conditioned to approximately 45 per cent. moisture content, at which value fungus growth is encouraged. Unsterilized controls were tested immediately and the remainder of the test-pieces given the appropriate treatment.

STERILIZATION AND INFECTION.

The samples were sterilized by autoclaving at 15-lb. pressure for 20 minutes in long glass tubes of 3 in. diameter plugged with cotton-wool. After sterilization the samples were infected by pouring from a pipette over the centre portion a suspension of spores of the fungi in sterile distilled water. The fungi used were *Ceratostomella coerulea* Münch, *C. pilifera* (Fr.) Winter, and *Diplodia natalensis* P. Evans. The cultures of the latter two were obtained through the courtesy of

R. W. Davidson of U. S. Department of Agriculture. After infection the tubes containing the test-pieces were kept at a constant temperature of 22° C. The fungi all grew rapidly over the surface of the test-pieces which were soon deeply stained.

The unsterilized samples were laid on cotton-wool in a flat enamelled dish and sprayed with a mixed suspension of spores of various staining fungi. This dish was also kept at 22° C. Stain developed somewhat irregularly, as some of the pieces naturally became infected with various moulds which tended to inhibit the growth of the blue stain fungi.

TESTING.

The periods of infection were decided after visual inspection of the development of stain on the test-pieces. The first batch of test-pieces was removed after 32 days, wiped clear of surface growth, and measured at the centre section to 1/1000 inch. Each test-piece was pulled apart in a Tensometer testing machine, using wedge grips and a head speed of 0·014 inch per second, to determine the maximum tensile load, from which the stress at failure, based on the minimum section, was calculated. The other groups were removed after 64 and after 94 days and tested in the same way. The moisture content at the time of test was also determined, but as in all cases this was well above the fibre saturation point of the timber and therefore had no influence on the strength, it has not been recorded in the tables.

Test-pieces exposed to general infection were all tested after 96 days, by which time many of them had developed extensive stain covering practically the whole of each test-piece.

RESULTS: (*a*) TENSILE STRENGTH.

The results of the tests are summarized in the accompanying table, which includes the percentage loss in strength, based on the sterilized controls where specific infection was used, and on their own unsterilized controls in the case of test-pieces exposed to general infection. The statistical significance of the loss is also given.

Sterilization alone was accompanied by loss in strength of the order of 2–3 per cent., well within the 5 per cent. limits of significant difference which the number of tests was designed to reveal.

After 32 days' incubation a loss of strength of 4–7 per cent., not statistically significant, however, was shown in all cases.

After 64 days' incubation little or no further reduction was shown with the test-pieces exposed to the action of *Ceratostomella* spp., but there was marked increase in loss of strength in the test-pieces exposed to the action of *Diplodia*; this loss was highly significant.

After 94 days' incubation there was a reduction in strength of the order of 12 to 14 per cent. for test-pieces exposed to the action of all these fungi.

A reduction in strength of about 12 per cent., after 96 days' exposure, also occurred in the case of the test-pieces exposed to general infection.

After test the broken cross-section of the test-piece was examined to determine

Summary of Results

Treatment			Tensile strength (lb. per sq. in.)			
Fungus	Period of infection (days)	No. of results	Mean value	Mean as percentage of sterilized control	Percentage loss in strength	Significance of difference*
Control	..	61	15,280	102·3	+2·3	N.S.
Control sterilized	..	54	14,940	..	..	N.S.
(1) *Ceratostomella coerulea*	32	60	13,900	93·0	7·0	N.S.
	64	57	14,070	94·2	5·8	N.S.
	94	56	13,240	88·6	11·4	S.
(2) *Ceratostomella pilifera*	32	54	14,260	95·4	4·6	N.S.
	64	52	14,110	94·4	5·6	N.S.
	94	52	13,230	88·5	11·5	S.
(3) *Diplodia natalensis*	32	60	14,060	94·1	5·9	N.S.
	64	62	12,380	82·9	17·1	S.
	94	61	12,830	85·9	14·1	S.
Unsterilized—general infection				*Percentage of unsterilized control*		
Control	..	57	15,710	..	..	..
Stained	96	62	13,830	88·0	12·0	S.

* N.S. = loss in strength not statistically significant.
S. = loss in strength statistically significant.

the depth of staining which had occurred. The observations made are tabulated below:

Fungus	Period (days)	Average degree of staining
Ceratostomella coerulea	32	Approximately half area of cross-section stained in most pieces.
	64	A few stained throughout, mostly with $\frac{1}{3}$ cross-sections stained.
	94	Some stained throughout, in the rest, $\frac{1}{2}$ to $\frac{2}{3}$ cross-section stained.
C. pilifera	32	Stained superficially, only a few with stain throughout.
	64	Mostly with approximately $\frac{2}{3}$ cross-section stained.
	94	Mostly stained throughout.
Diplodia natalensis	32	Mostly with light staining throughout.
	64	Stained throughout.
	94	Stained throughout.
General infection	96	Irregular. Some stained deeply, some with little or no stain.

The superficial nature of the staining in the groups tested after 32 and 64 days was probably due to the moisture content of the samples being rather above the optimum for these fungi. Some condensation on the test-pieces occurred after

sterilization and this raised the moisture content above the 45 per cent. aimed at. As the samples dried out somewhat in the later stages of the experiment so the staining became deeper.

DISCUSSION OF RESULTS.

Previous tests (1) had shown that blue stain produced by *Ceratostomella coerulea* or by other similar organisms had no appreciable effect on the compressive strength or the bending strength of the sapwood of Scots pine but that it caused a marked reduction in toughness. The maximum bending strength of a softwood is closely related to its compressive strength since, in general, initial failure occurs on the compression side of the bent specimen. Toughness, however, involves also the tensile strength of the timber since it is dependent not only on the load which the specimen can carry but also on the degree to which it will bend without actual fracture, i.e. on the tensile strength of the outer fibres of the specimen.

The results of the present tests on tensile strength are thus in agreement with those previously reported for stain produced by *Ceratostomella* sp.

The fungus *Diplodia natalensis* was not used in the previous tests on Scots pine. Its effects on tensile strength as obtained from the tests here reported were more marked than those produced by *Ceratostomella*, and in this respect it is of interest to note that the allied fungus *Botryodiplodia theobromae* caused not only very marked reduction in toughness but also appreciable reduction in the bending strength of obeche (*Triplochiton scleroxylon*)(3). The indications are therefore that this type of staining fungus is more harmful to the timber than *Ceratostomella* spp. Microscopic examination of wood infected with *Diplodia* shows that its hyphae penetrate the walls of the tracheids much more frequently than do those of *Ceratostomella* spp. which are mainly confined to the ray cells.

SUMMARY.

Tests have been made to determine the effects on the tensile strength of Corsican pine sapwood of attack by *Ceratostomella* sp. and *Diplodia* sp., two sap-staining fungi, and also of general infection by various types of staining fungi.

After 64 days' exposure the loss in tensile strength due to attack by *Ceratostomella* spp. was 5–6 per cent. and that due to *Diplodia* sp. 17 per cent. After 94 days the losses were 11–12 per cent. and 14 per cent. respectively. After 96 days the loss due to the general infection amounted to 12 per cent.

The work described above was carried out as part of the programme of the Forest Products Research Board and is published by permission of the Department of Scientific and Industrial Research.

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A COMPARATIVE STUDY OF THE STRUCTURE AND CHEMICAL COMPOSITION OF TENSION WOOD AND NORMAL WOOD IN BEECH (*FAGUS SYLVATICA* L.)

By K. Y. CHOW

I. INTRODUCTION.

TREES may develop leaning stems as a consequence of mechanical force such as the action of wind, landslides, &c., or due to phototropism, as in the case of trees on the edge of woods. The abnormal tissue formed under these conditions is known as tension wood or compression wood, according to whether it occurs on the side of the stem under tensile or compressive stress respectively. Generally in coniferous trees compression wood is developed, and tension wood in broad-leaved trees.

The reasons for the formation of these abnormal types of tissue are not precisely understood and their occurrence cannot always be explained by reference to mechanical forces or growth movements (tropisms). Thus, although tension wood in broad-leaved trees is generally found on the upper side of leaning stems or branches, it sometimes occurs on the lower side or in a lateral position and may even show a progressive movement from one sector of the stem to the next. Frequently, but not invariably, tension wood is associated with eccentric growth of stem or branch, occurring in the wider parts of the eccentric rings.

A brief review of the characteristic properties of tension wood as described by previous investigators is as follows:

The structure, according to Jaccard's description (10), is characterized by a more compact grouping and regular arrangement of the fibres, a more considerable development of the rays, a reduction in the number of vessels, and longer fibres but with thinner walls and wider lumina. However, Böning (1) states that tension-wood fibres have strongly thickened walls and are weakly lignified. Clarke (5), working on beech, found that with standard micro-stains the gelatinous-looking layers of tension-wood fibres give the reactions of so-called non-lignified walls. He also found that when tension wood is turned on a lathe the turnings come off in long, unbroken, pliable ribbons, whereas those from normal wood are short broken chips, inclined to be brittle. On rotary planing-machines tension wood takes a distinctly more woolly finish than normal wood. On sawn longitudinal surfaces a similar woolliness is apparent, and on sawn end-grain surfaces the tension wood may be distinguished by its more lustrous, silvery appearance. In shrinkage, tension wood and normal wood shrink more or less equally in the radial direction, but in the tangential direction tension wood shrinks rather more than normal specimens of similar density, whilst in the longitudinal direction the shrinkage of tension wood is abnormally high.

According to Clarke (5), tension wood, in the green condition, as compared with normal wood of similar density, was found to be exceptionally weak under

compression parallel to the grain; in tensile strength and toughness, however, it was on the average slightly stronger than normal wood of the same density.

Jacobs (11), by examining a stem of *Eucalyptus gigantea* containing a crescent of tension wood, demonstrated that the natural fibre tension was considerably greater in the tension wood than in normal wood. He also quotes Münch (12) as describing tension-wood fibres differing from those of normal wood in having, besides the lignified primary and secondary walls, a tertiary wall which he represents as being unlignified and composed of cellulose and hemicellulose. This gelatinous-looking tertiary layer is very thick, frequently filling up the fibre lumen.

In the sixteenth annual report of the Council for Scientific and Industrial Research (Australia) (6) it is stated that the abnormal collapse of tension wood in *Eucalyptus* during air-drying did not respond to the normal reconditioning processes. It is also stated that tension wood was much higher in density than normal wood from the same tree, but tension wood of *Nothofagus cunninghamii* was poor in bending quality and lower in impact strength.

In an examination of *Eucalyptus regnans* Dadswell (7) records a cellulose content of 63·7 per cent. and a lignin content of 16·0 per cent. for tension wood. Normal wood from the same tree had a cellulose content of 59·7 per cent. and a lignin content of 22·3 per cent.

Tension wood has been found to have an important effect on the technical properties and uses of timber. As beech frequently develops tension wood, and suitable material was available for study, this species was selected as the subject for the present investigation. The objects of the investigation were:

(*a*) to make a comparative study of the structure of tension wood and normal wood;
(*b*) to determine some of the physical properties of tension wood;
(*c*) to carry out a chemical analysis of tension wood and normal wood;
(*d*) to compare the relationship of microscopic structure, physical properties, and chemical composition of tension wood and normal wood.

II. MATERIAL.

The material for the main part of the investigation was a square-sawn specimen of English beech, measuring approximately 2 feet long by 4 inches by 4 inches. The specimen showed an abrupt transition from normal wood to tension wood. In seasoning, the specimen had split owing to the abnormally high longitudinal shrinkage of the tension wood. Cross-sectional disks, 1 inch thick, were cut from each end and from the middle of the specimen for anatomical and physical investigation, and the remainder provided material for chemical analysis. Microscopic examination showed that the split passed through the region of transition from normal wood to tension wood.

III. STAINING REACTIONS OF NORMAL WOOD AND TENSION WOOD.

Many reagents, both organic and inorganic, have been proposed by chemists and botanists as a test for lignification. Clarke (4) used phloroglucin and hydrochloric acid, and also a combination of safranin and fast green, to distinguish sections of normal wood and tension wood under the microscope. The latter

especially gave a very satisfactory contrast, normal wood staining predomir red and tension wood green. Chlor-zinc-iodine was also found to be satisfa for this purpose, the only disadvantage being that the colour obtained was r fugitive. This reagent stains a cross-section of normal wood yellow; tension is coloured a distinctive dark brown or deep violet shade. The differences i staining reactions of the fibre walls in normal wood and tension wood after ment with chlor-zinc-iodine are summarized in the following table:

TABLE I. *Comparison of the Staining Reactions of Normal Wood and Tension with Chlor-zinc-iodine*

	Normal wood	*Tension wood*
Primary wall	Yellow or yellowish	Reddish-brown
Secondary wall, outer layer	Uniformly yellow or yellowish	Pale yellow, sometimes re brown
Secondary wall, middle layer	,, ,,	Reddish-brown (gelatinou pearance)
Secondary wall, inner layer	Light reddish-brown	Dark reddish-brown

In both types of tissue the fibre walls are more or less swollen by chlor- iodine. In tension wood the swelling is more pronounced, the fibre lumen reduced to a mere slit.

Chlor-zinc-iodine can also be used to detect tension wood by applying i clean-cut end-surface, tension wood being stained purplish or reddish-brow normal wood yellow. The effect is not permanent.

IV. COMPARATIVE STRUCTURE OF NORMAL WOOD AND TENSION WO(

1. *Percentage of Vessels and Fibres.*

The percentage volume occupied by vessels and fibres in normal wooc tension wood was determined from photomicrographs of representative sections. In order to cover any possible variation due to rate of growth, determinations were made on carefully matched pairs of annual rings of different widths, designated wide (3·2 mm.), medium (1·9 mm.), and n (0·9 mm.), respectively. The areas measured were also matched as regarc number and size of rays, very wide rays being avoided. The percentage of wood volume occupied by each tissue was assessed from photomicrograp cross-sections by the cutting-out and weighing method. Three separate c minations were made on each specimen; the results are shown in full in Tab which gives the values for vessel volume and the complementary values for volume in normal wood and tension wood of three different ring-widths. clear that, in all three ring-widths, tension wood has a significantly lower volume and a correspondingly higher fibre volume than normal wood. In n wood the percentage fibre volume increases with decreasing ring-width difference between wide and medium rings is not statistically significant ($t =$ but that between medium and narrow rings is definitely significant ($t = 3·9$ also must be the still greater difference between wide and narrow ring

tension wood the results are not so consistent, the medium ring showing a significantly smaller percentage of vessel volume than either the wide or narrow rings; the narrow ring, in turn, showing a significantly greater vessel volume than the wide ring. In general, therefore, the percentage vessel volume for all three

TABLE II. *Percentage Volume of Vessels and Fibres in Normal Wood and Tension Wood*

	Vessel volume %				*Fibre volume %*	
			Comparison			
Ring-width	*Normal wood*	*Tension wood*	*Value of 't'*	*Significance*	*Normal wood*	*Tension wood*
Wide	26·8	21·8	6·91	S*	73·2	78·2
	29·2	23·0			70·8	77·0
	29·0	21·4			71·0	78·6
Mean	28·3	22·1			71·7	77·9
Medium	33·5	15·8	6·13	S*	66·5	84·2
	26·3	16·0			73·7	84·0
	31·5	18·0			68·5	82·0
Mean	30·4	16·6			69·6	83·4
Narrow	41·8	25·0	7·5	S*	58·2	75·0
	39·8	25·7			60·2	74·3
	38·0	29·4			62·0	70·6
Mean	39·9	26·7			60·1	73·3
Grand Mean	32·9	21·8			67·1	78·2

S* = Significant at $P = 0{\cdot}05$ level.

ring-widths is less for tension wood than for normal wood and the percentage fibre volume is consequently greater. In both normal wood and tension wood the percentage vessel volume in wide and medium rings is less than that in narrow rings and the percentage fibre volume is correspondingly greater.

It should be noted that it was impracticable to distinguish diffuse wood parenchyma cells from fibres in the photomicrographs of cross-sections. The figures for the percentage of fibres, therefore, actually refer to fibres and parenchyma together. Wood parenchyma in beech occurs in two forms, diffuse and terminal, the former mostly in the outer part of the growth rings as scattered cells or in short tangential lines. Visual comparison of sections showed a somewhat larger proportion of parenchyma (*a*) in wide rings than in narrow rings and (*b*) in tension wood than in normal wood, but the total amount of parenchyma was generally so small that its inclusion with the fibres was considered to be without influence on the results.

2. *Dimensions of Fibres.*

Measurements of the length, width, and wall thickness of fibres were carried out on material macerated by Franklin's method (8), using a mixture of equal

parts by volume of hydrogen peroxide (20 vols.) and glacial acetic acid at a temperature of 60° C. Samples for maceration were carefully selected from normal wood and tension wood so as to eliminate any possible influence of ring-width or position in the annual ring on the results. With samples of uniform size treated under identical conditions it was observed that tension wood became macerated more quickly than normal wood. In all cases measurements of width and wall thickness were made at the widest part of the fibre.

A large number of measurements was necessary to establish whether the slight dimensional differences between the fibres of normal wood and tension wood were significant. The results are summarized in Table III. They show that the tension-wood fibres are slightly longer and narrower than those of normal wood and that the fibre walls are appreciably thicker in tension wood than in normal wood. This last feature is readily apparent when cross-sections are examined under the microscope at a suitable magnification (see Figs. 1 and 2).

TABLE III. *Comparison of the Dimensions of Fibres of Normal Wood and Tension Wood*

	Normal wood			*Tension wood*			*Comparison*	
	No. of measurements	*Mean*	*S.D.*	*No. of measurements*	*Mean*	*S.D.*	*Value of 't'*	*Significance of difference*
Length (mm.)	1,000	1·32	±0·23	1,000	1·34	±0·21	2·84	S**
Width (μ)	800	20·1	±3·08	800	18·6	±3·00	9·94	S**
Wall-thickness (μ)	800	5·80	±1·06	800	6·04	±1·22	4·20	S**

S** = Significant difference at $P = 0{\cdot}01$ level.

3. *Dimensions and Frequency of Vessels.*

Visual comparison of cross-sections shows that the vessels in tension wood are smaller and less numerous than in normal wood (see Figs. 1 and 2). Measurements of tangential and radial diameters were made on cross-sections of different ring-widths. Every vessel in a radial strip across the annual ring was measured. The results are summarized in Table IV. They show that the difference in size is due

TABLE IV. *Comparison of the Diameters of Vessels of Normal Wood and Tension Wood*

	Normal wood			*Tension wood*			*Comparison*	
	No. of measurements	*Mean*	*S.D.*	*No. of measurements*	*Mean*	*S.D.*	*Value of 't'*	*Significance of difference*
Tangential diameter (μ)	220	47	±10·7	172	47	± 9·3	0·44	N.S.
Radial diameter (μ)	220	62	±16·1	172	55	±13·0	4·80	S*

N.S. = Not significant at $P = 0{\cdot}05$ level. S* = Significant at $P = 0{\cdot}05$ level.

to the smaller radial diameter of the tension-wood vessels; there is no significant difference in tangential diameter.

The number of vessels per square millimetre was counted on cross-sections of three different ring-widths. The results, as summarized in Table V, show that in the wide and medium annual rings vessels are less numerous in tension wood than in normal wood, but in the narrow annual ring the position is reversed.

TABLE V. *Comparison of the Number of Vessels per square millimetre in Normal Wood and Tension Wood*

	Normal wood		*Tension wood*		*Comparison*	
	Mean	*S.D.*	*Mean*	*S.D.*	*Value of 't'*	*Significance of difference*
Wide annual ring .	85	..	67	..	..	..
Medium annual ring.	97	..	63	..	..	..
Narrow annual ring .	126	..	141	..	..	..
Average . . .	103	±21·09	90	±43·93	2·12	N.S.
Average of the wide and medium annual rings	91	± 6·00	65	± 1·30	12·68	S*

N.S. = Not significant at $P = 0{\cdot}05$ level. S* = Significant at $P = 0{\cdot}05$ level.

Statistical comparison of the average of the three ring-widths shows no significant difference between tension wood and normal wood in this respect. A similar comparison of the average of the wide and medium rings, however, shows a highly significant difference of the order of 30 per cent. Tension wood is generally associated with wide rather than narrow rings and it is reasonable to regard the wide and medium rings as being more typical of tension wood than the narrow ring. Moreover, when the smaller size of the tension-wood vessels is taken into consideration, the percentage area of cross-section occupied by vessels in the narrow ring is seen to be less in tension wood than in normal wood, as previously found by direct measurement (see Table II). It may be inferred, therefore, that, in general, the number and size of vessels and the total area (or volume) occupied by vessels are less in tension wood than in normal wood.

4. *Rays.*

The rays in beech wood are of two distinct types (sizes), large rays from about 10 to 20 cells in width at the widest part and small rays varying from 1 to 5 cells in width. The ray volume in normal wood and tension wood was assessed from low-power (×25) photomicrographs of tangential sections by cutting out and weighing. The sections were cut from near the middle of the annual rings in all cases. Although examination of a large number of sections in the course of the investigation gave the impression that tension wood contained a larger proportion of ray tissue than normal wood, the quantitative determination of ray volume on a limited number of sections revealed no significant difference in this respect. These results, as summarized in Table VI, are considered to be inconclusive owing to the limited number of observations.

TABLE VI. *Comparison of the Ray Volume of Tension Wood and Normal Wood*

	No. of tests	*Ray volume, %*	*S.D.*	*Value of 't'*	*Significance of difference*
Tension wood	3	21·7	±1·44	0·61	N.S.
Normal wood	3	20·9	±1·15	..	..

N.S. = Not significant at $P = 0{\cdot}05$ level.

The frequency of the rays was determined by counting the number per millimetre, measured in the tangential direction on tangential sections. The results are summarized in Table VII. They show no significant difference between normal wood and tension wood.

TABLE VII. *Comparison of the Number of Rays per millimetre of Normal Wood and Tension Wood*

	Normal wood			*Tension wood*			*Comparison*	
	No. of tests	*Mean*	*S.D.*	*No. of tests*	*Mean*	*S.D.*	*Value of 't'*	*Significance of difference*
No. of rays per mm.	100	8·08	±1·18	100	8·36	±1·15	1·697	N.S.

N.S. = Not significant at $P = 0{\cdot}05$ level.

5. *The Microscopic Structure of Tension-Wood Fibres.*

The peculiar nature of the secondary walls of beech tension-wood fibres had been described by Clarke (5). Microscopic examination of cross-sections cut from the material under investigation and stained with chlor-zinc-iodine served to confirm his observations (see 'Staining Reactions of Tension Wood and Normal Wood' and Table I above). A structural peculiarity of tension-wood fibres which has apparently not been described previously is the presence of short discontinuous spiral markings on the walls, sometimes approximating in shape to the letters W, M, V, and N, as seen in isolated wood fibres prepared by maceration (Fig. 3). These markings appear more distinct when the fibres are treated with chlor-zinc-iodine or when they are examined between crossed nicols. Besides being discontinuous they are irregularly spaced. After dehydration of the macerated fibres with acetone and ether, the edges of the markings acquire a serrated appearance (Fig. 5). When treated with caustic soda solution, which has the effect of swelling the cell wall, the spiral markings become practically invisible, but they reappear when the fibres are washed in water. Treatment with dilute acetic acid renders them more distinct.

As these spiral markings are not generally visible in longitudinal sections prepared in the ordinary way, it is conceivable that they may have been produced as a result of chemical attack by the reagents (acetic acid and hydrogen peroxide) used in the maceration. In order to eliminate this possibility as far as possible, thin tangential sections were treated by one of the mildest known methods of

delignification, namely, chlorination followed by extraction with hot alcoholic mono-ethanolamine. Even when treated in this way tension-wood fibres still exhibited the characteristic markings. Furthermore, it could be seen that some of the markings ran continuously across two or three adjacent fibres (Fig. 7).

The possibility of the markings being induced by drying stresses was also considered. To examine this possibility a small leaning beech-tree was specially felled and samples of tension wood taken and macerated immediately, while the wood was still in the fresh, green condition. Matched samples were thoroughly oven-dried and then treated in the same way. Microscopic examination showed spiral markings equally distinct in both lots of material.

Photomicrographs of isolated fibres from tension wood and normal wood of beech treated in various ways are shown in Figs. 3 to 6.

Similar spiral markings were observed in tension-wood fibres of English oak, African mahogany (*Khaya* sp.), birch, and elm.

It has been demonstrated repeatedly that in wood subjected to compression parallel to the grain the early stages of permanent deformation appear as 'slip planes' or incipient compression failures (13, 14). The results of the present investigation lead the writer to the conclusion that the spiral markings observed in tension wood are the direct result of mechanical forces acting on the wood of the standing tree. They are in fact incipient tension failures and will be referred to as such in the subsequent portions of this paper.

Jacobs (11) has demonstrated the existence of considerable tensile forces in the tension wood of *Eucalyptus* trees, and it is reasonable to assume that these forces acting continuously over a long period may result in permanent deformation of the fibre walls. There are indications that the intensity of the microscopic failures varies with the degree of development of tension wood; they are not so pronounced in poorly developed tension wood. Admittedly, similar failures have not been observed in mechanical test specimens subjected to tension parallel to the grain, but this may well be due to the different conditions prevailing in the wood of a standing tree and in a specimen tested under laboratory conditions. There is obviously a need for further research in this field.

V. PHYSICAL PROPERTIES OF NORMAL WOOD AND TENSION WOOD.

The amount of material available did not permit of a detailed comparison of the physical properties of tension wood and normal wood. Opportunity was taken, however, to make a small number of observations on carefully matched samples, each measuring about 1 inch cube. The results are summarized in Table VIII. They are in agreement with those of Clarke (5) which were based on a large number of observations.

VI. CHEMICAL COMPOSITION OF TENSION WOOD AND NORMAL WOOD.

It has been indicated previously that microchemical staining reactions can be used successfully to differentiate visually between tension wood and normal wood. Staining reactions by themselves are not generally regarded as a reliable single index of such factors as degree of lignification, however, so that comparative

chemical analyses of tension wood and normal wood were considered desirable. All analytical determinations were carried out on material which had first been classified by staining tests as consisting either entirely of tension wood or entirely

TABLE VIII. *Comparison of Physical Properties of Normal Wood and Tension Wood*

	Normal wood	*Tension wood*	*Comparison*	
	Mean of 3 tests	*Mean of 3 tests*	*Value of 't'*	*Significance of difference*
Moisture content per cent.	9·62	10·64	..	..
Specific gravity	0·60	0·67	6·10	S*
Volumetric shrinkage per cent. (air-dry to oven-dry)	7·60	6·54	1·24	N.S.
Volumetric swelling per cent. (oven-dry to green)	25·74	25·90	0·07	N.S.
Longitudinal shrinkage per cent. (air-dry to oven-dry)	0·11	0·28	7·67	S*
Longitudinal swelling per cent. (oven-dry to green)	0·36	0·76	8·63	S*

N.S. = Not significant at $P = 0{\cdot}05$ level. S* = Significant at $P = 0{\cdot}05$ level.

Moisture content based on oven-dry weight, specific gravity based on oven-dry weight and green volume; volumetric and longitudinal shrinkage from air-dry to oven-dry based on green dimensions, and swelling properties from oven-dry to green based on oven-dry dimensions.

of normal wood. Separate samples of tension wood and normal wood were converted to sawdust. Grinding of sawdust was avoided as this operation tends to detract from the accuracy of cellulose and lignin determinations (2). Each sample of sawdust was screened and the 20–60-mesh and 60–100-mesh fractions were retained for analysis (Table IX). The analytical methods employed were those in current use at the Forest Products Research Laboratory, Princes Risborough, England. Holocellulose was determined by the procedure outlined by Van Beckum and Ritter (15). Each result recorded (Table IX) for 20–60-mesh material represents the mean of two determinations, and each recorded result for 60–100-mesh material represents the mean of 2 to 8 separate determinations. The results were examined statistically in order to test the significance of the observed differences in composition between tension wood and normal wood, respectively. The significant differences were mostly at the $P = 0{\cdot}01$ level.

Consideration of Chemical Results.

The data in Table IX illustrate the effect of particle size of wood on the analytical results. Owing to the greater specific surface exposed to solvents, solubility in water, alcohol : benzene and 1 per cent. sodium hydroxide is higher for 60–100-mesh material than for 20–60-mesh material. Variation in particle size of wood within the limits indicated in the table appears to have little or no influence on the results of cellulose, lignin, pentosan, and methoxyl determinations. The observed effect of particle size of wood on the results of holocellulose determinations is of doubtful significance.

TABLE IX. *Chemical Analysis of Normal and Tension Wood of Beech*

[All results except 13, 18, 19 and 20 expressed as percentages by weight of oven-dry (105° C.) wood]

	Normal wood				*Tension wood*				*Comparison of normal and tension wood*			
	20–60-mesh		*60–100-mesh*		*20–60-mesh*		*60–100-mesh*		*20–60-mesh*		*60–100-mesh*	
	No. of determinations	*Mean %*	*No. of determinations*	*Mean %*	*No. of determinations*	*Mean %*	*No. of determinations*	*Mean %*	*Value of 't'*	*Significance of difference*	*Value of 't'*	*Significance of difference*
1. Moisture content	2	7·60 ± 0·00	2	8·02 ± 0·00	2	7·52 ± 0·07	2	8·04 ± 0·01	..	..	..	..
2. Cold-water soluble	2	2·42 ± 0·01	4	2·43 ± 0·02	2	3·87 ± 0·01	4	3·95 ± 0·03	102·5	S**	54·3	S**
3. Hot-water soluble	2	3·34 ± 0·25	2	3·49 ± 0·01	2	5·01 ± 0·11	4	5·01 ± 0·07	8·0	S*	16·3	S**
4. Alcohol-benzene soluble	2	1·92 ± 0·04	10	2·15 ± 0·07	2	1·63 ± 0·09	4	2·14 ± 0·01	3·2	N.S.	0·5	N.S.
5. 1 per cent. NaOH soluble	2	20·68 ± 0·02	4	21·34 ± 0·09	2	19·32 ± 0·07	4	20·30 ± 0·07	23·3	S**	10·8	S**
6. Cross and Bevan cellulose	2	57·37 ± 0·32	6	57·08 ± 0·19	3	62·16 ± 0·07	8	62·06 ± 0·05	245·0	S**	36·5	S**
7. α-cellulose	..	..	2	41·15 ± 0·45	..	..	2	49·68 ± 1·63	..	..	4·27	B.L.C.
8. Pentosan IN cellulose	2	15·05 ± 0·23	2	15·51 ± 0·21	2	10·44 ± 0·21	2	10·35 ± 0·06	18·6	S**	29·9	S**
9. Pentosan TOTAL	2	26·09 ± 0·32	2	26·58 ± 0·25	2	19·01 ± 0·17	4	19·08 ± 0·19	25·7	S**	34·1	S**
10. Pentosan NOT in cellulose (9) − (8)	..	11·04 ± 0·22	..	11·07 ± 0·14	..	8·57 ± 0·12	..	8·73 ± 0·18	13·8	S**	14·6	S**
11. Lignin	2	19·70 ± 0·10	8	19·51 ± 0·15	2	15·40 ± 0·07	8	15·10 ± 0·09	48·5	S**	26·8	S**
12. Methoxyl IN lignin	1	4·25	2	4·21 ± 0·07	1	3·48	2	3·24 ± 0·03	..	..	16·5	S**
13. Methoxyl IN lignin as % of (11)	1	21·65	2	21·30 ± 0·36	1	22·62	2	21·30 ± 0·18	..	..	0·02	N.S.
14. Methoxyl TOTAL	1	7·46	2	7·42 ± 0·05	1	5·98	2	5·40 ± 0·03	..	..	45·2	S**
15. Methoxyl NOT in lignin (14) − (12)	..	3·21	..	3·22 ± 0·10	..	2·50	..	2·16 ± 0·00	..	..	30·3	S**
16. Holocellulose	2	71·16 ± 0·14	4	69·56 ± 0·32	2	71·79 ± 0·10	4	71·99 ± 0·12	0·58	N.S.	7·47	S**
17. Ash	2	0·29 ± 0·01	..	..	2	0·43 ± 0·02	..	..	8·85	S*	..	..
18. pH value	4	4·49 ± 0·02	..	..	4	4·43 ± 0·03	..	..	2·4	N.S.	..	..
19. Number of chlorinations for cellulose determination	..	6	..	5	..	5	..	4	..	..	..	..
20. Number of chlorinations for holocellulose determination	..	8	..	7	..	8	..	7	..	..	..	..
21. TOTAL (3) + (6) + (10) + (11) + (15)	..	94·66 ± 0·47	..	94·43 ± 0·28	..	93·64 ± 0·19	..	93·06 ± 0·22	..	..	..	..

N.S. = Difference NOT significant at $P = 0{\cdot}05$ level.
S* = Difference significant at $P = 0{\cdot}05$ level.
S** = Difference significant at $P = 0{\cdot}01$ level.
B.L.C. = Border-line case.

In general, the results in Table IX show that tension wood has a higher ash content, a higher solubility in water, and a lower solubility in 1 per cent. sodium hydroxide than normal wood. All of the observed differences are statistically significant. The lignin content of tension wood is significantly lower than the lignin content of normal wood. This finding is reflected in the methoxyl contents of the two types of wood. The total methoxyl content of tension wood is significantly lower than that of normal wood, but the methoxyl content of the isolated lignin is essentially the same for both types of wood. The indications are therefore that, although tension wood is less highly lignified than normal wood, both contain the same type of lignin. The relatively low lignin content observed for tension wood offers confirmation of the earlier observations of Dadswell (7). The data in Table IX also confirm Dadswell's observation that the Cross and Bevan cellulose content of tension wood is higher than that of normal wood by an amount which is, statistically, highly significant.

It is observed (Table IX) that the Cross and Bevan cellulose isolated from tension wood has a higher alpha cellulose content and a lower pentosan content than the corresponding product isolated from normal wood. Other things being equal, therefore, it is indicated that tension wood contains a higher proportion of cellulose of relatively long molecular chain length than normal wood. A similar conclusion is reached from a consideration of the holocellulose isolated from the two types of wood.

The early exponents of the holocellulose determination were of the opinion that if an alcoholic solution of an organic base, such as pyridine or monoethanolamine, is used as an extractant after chlorination, instead of the aqueous solution of sodium sulphite normally used in most forms of the original Cross and Bevan technique for isolating cellulose, only lignin is removed in solution, and the total carbohydrate fraction of wood, comprising all of the cellulose and hemicellulose (including pentosans), is left behind as a fibrous residue. More recent investigations are beginning to reveal that, in practice, the so-called holocellulose does not consistently comprise the total carbohydrate fraction of wood. In common with Freeman and Peterson (9), for example, it has been found in the course of the present study that the method of Van Beckum and Ritter (15) provides no definite end-point indicative of the removal of the last traces of lignin. In this respect the chlorine : sodium sulphite colour reaction of lignin and related substances (3) is a much more satisfactory indicator. It was found by experiment that, in applying the holocellulose determination to the material used in this study, 20–60-mesh wood required eight 5-minute chlorinations (and extractions), and 60–100-mesh wood required seven chlorinations (and extractions) in order to obtain fibrous end-products which gave negative tests for lignin with chlorine and sodium sulphite. In both cases tension wood and normal wood required the same number of treatments. The results are given in Table IX. It is observed that the results for 20–60-mesh material show no significant difference with respect to holocellulose content between tension wood and normal wood. The holocellulose content of 60–100-mesh tension wood, however, was greater than that of 60–100-mesh normal wood by an amount which, although statistically significant, was not

as great as the difference found between the Cross and Bevan cellulose contents of tension wood and normal wood, respectively (Table IX).

Although the experimental data (Table IX) show that by applying a standard number of chlorinations it was possible to isolate the holocellulose from both tension wood and normal wood in closely similar percentage amounts, the two products were entirely different in composition. Whilst the normal wood holocellulose had a pentosan content of 24·84 per cent., the corresponding product from tension wood had a pentosan content of only 14·44 per cent. In the case of normal wood the pentosan in holocellulose accounts for approximately 65 per cent. of the total pentosan present in the original wood, and in the case of tension wood only approximately 55 per cent. of the total pentosan in the original wood is isolated as part of the holocellulose. Thus whilst in neither normal wood nor tension wood can the holocellulose be described as the total polysaccharide fraction of the cell wall, the experimental results can be used to better advantage than the Cross and Bevan cellulose results in order to obtain an apparently satisfactory summative analysis of wood (Table X).

TABLE X. *Tentative Summative Analyses of 60–100-mesh Normal Wood and Tension Wood*

	Normal wood	*Tension wood*
Holocellulose-pentosan-free	52·28	61·59
Pentosan in holocellulose	17·28	10·40
Pentosan not in holocellulose [Total pentosan (Table IX)—pentosan in holocellulose]	9·30	8·68
Lignin	19·51	15·10
Soluble in hot water	3·50	5·00
Total	101·87	100·77

(Results expressed as percentages by weight of oven-dry original wood in each case.)

In view of the present lack of knowledge concerning the constitution of the several recognized components of wood, and bearing in mind that in analysis each of these components is determined on a separate aliquot of the starting material, the fact that each of the totals in Table X closely approaches 100 per cent. may be fortuitous, and therefore too much stress should not be laid upon it. As they stand, however, the data in Table X provide reinforcement for the view that tension wood contains a higher proportion of cellulose of relatively long molecular chain length than normal wood. Other things being equal, therefore, tension wood should have a higher tensile strength than normal wood.

VII. THE RELATIONSHIPS BETWEEN CHEMICAL COMPOSITION, MOLECULAR STRUCTURE OF THE CELLULOSE, AND PHYSICAL PROPERTIES OF TENSION WOOD.

It has been found by the photographic method that, per unit of bulk volume, tension wood contains a higher proportion of fibres than normal wood. It has further been established that, whilst the external diameter of tension-wood fibres is smaller than that of normal wood fibres, tension-wood fibres have significantly

thicker cell walls. Thus, per unit of bulk volume, tension wood contains the greater proportion of wood substance and its relatively high bulk density is thereby explained. That this is not the sole factor responsible for the relatively high density of tension wood is brought out by a consideration of the swelling phenomena exhibited by isolated, lignin-free fibres.

When cellulosic fibres swell under the influence of reagents such as concentrated sulphuric acid, sodium hydroxide, cuprammonia, &c., they increase in external diameter and decrease in length. This connotes a strong tendency for the cellulose fibrils comprising the cell wall to assume, as swelling progresses, a flatter spiral arrangement with respect to the long axis of the fibre itself. It therefore follows that, unless this factor is taken into account, no measurement of the angle of inclination of fibrils in a swollen fibre is a correct measurement of fibrillar orientation in the untreated fibre. It has been found in the present study that in the majority of cases examined isolated tension-wood fibres swell much more readily than normal wood fibres. Moreover, although the original external diameter of tension-wood fibres is, on the average, smaller than that of normal wood fibres, when swollen in contact with the reagents mentioned above, the external diameter of tension-wood fibres was generally found to be greater than that of normal wood fibres exposed to the same reagents.

These observations afford a strong indication that in the untreated condition the cell walls of tension-wood fibres are intrinsically more dense than those of normal wood fibres. In other words, within the cell walls of tension-wood fibres there is a closer packing together of cellulose chain molecules than exists in the cell walls of normal wood fibres. From this it may be reasoned that, on the average, the cellulose chain molecules of untreated tension-wood fibres, as opposed to untreated normal wood fibres, are relatively more highly orientated in the direction of the long axes of the fibres and therefore of the long axis of the tree itself.[1] The greater overall breadth and the flatter spiral arrangement of the fibrils observed in greatly swollen, isolated tension-wood fibres, in comparison with similarly treated normal wood fibres, may rightly be regarded as an artifact. Furthermore, the indications that tension wood is formed during growth under the influence of abnormally high tensile forces, acting mainly in the direction of the long axis of the tree, favour the likelihood of a high degree of orientation of the cellulose chain molecules and fibrils in the direction of that axis.

It has been deduced in the previous section of this discussion that, on purely chemical grounds, tension wood should be stronger in tension than normal wood. Another factor connoting a relatively greater tensile strength in tension wood is the high degree of orientation of its cellulose chain molecules, to which reference has just been made. The fact that when submitted to tensile strength tests tension wood is little, if any, stronger than normal wood therefore requires explanation. The apparent paradox is readily explained on the assumption that the spiral markings shown to be present in tension-wood fibres are, in fact, incipient tension failures brought about by abnormal conditions of growth in the standing tree.

[1] This conclusion has been confirmed by X-ray data obtained at Leeds University by Drs. Preston and Ranganathan, who will publish their results in a separate communication.

One striking feature of tension wood which has not yet been adequately explained is its abnormal longitudinal shrinkage. Hitherto the general assumption has been made that this phenomenon is associated with the angle of inclination of the cellulose fibrils to the long axes of the fibres. On this assumption, a flat spiral arrangement of the fibrils should connote a relatively high degree of longitudinal shrinkage of wood on drying below the fibre saturation point. The present study has revealed that the assumption of a relatively flat spiral arrangement of the cellulose fibrils in tension-wood fibres in the natural state is no longer tenable, so that some other structural feature must be held to account for the abnormal longitudinal shrinkage of tension wood. This factor may be at hand in the spiral markings in the walls of tension-wood fibres. These markings might be regarded as evidence of minute and irregularly distributed transverse cracks in the fibre walls, indicative of a stretched condition in green tension wood. It has been observed that, when green wood is dried, these cracks tend to close. It may be, therefore, that the closing of innumerable cracks of this type and distribution accounts, in large measure, for the abnormal longitudinal shrinkage of tension wood. On the other hand, X-ray evidence which is still under consideration at Leeds University may provide an alternative explanation of the phenomenon.

SUMMARY.

1. The anatomical structure and chemical composition of tension wood and normal wood in beech (*Fagus sylvatica* L.) are compared.

2. The staining reactions of the two types of wood are described. Chlor-zinc-iodine is a useful reagent for distinguishing tension wood from normal wood under the microscope. It can also be used to detect tension wood by applying it to a clean-cut end-surface, tension wood being stained purplish or reddish-brown and normal wood yellow.

3. Tension wood has a more compact anatomical structure than normal wood, as shown by the larger proportion of fibres, the greater thickness of the fibre walls, the smaller size and smaller number of vessels per unit area, and the smaller proportion of vessels.

4. Tension-wood fibres are characterized by short, discontinuous spiral markings in the walls, which are here described for the first time. They are considered to be *incipient tension failures*, resulting from mechanical forces acting on the wood of the standing tree.

5. The findings of previous investigations, that tension wood has a higher specific gravity and a greater longitudinal shrinkage than normal wood, are confirmed.

6. Tension wood has a higher ash content, a higher solubility in water, and a lower solubility in 1 per cent. sodium hydroxide than normal wood.

7. It is confirmed by chemical analysis that tension wood is less highly lignified and has a higher cellulose content and lower pentosan content than normal wood. It is further indicated that the cellulose in tension wood is of longer average molecular chain length than the cellulose in normal wood.

8. Evidence is given to support the view that the cellulose chain molecules in

untreated tension-wood fibres, as opposed to untreated normal wood fibres, are relatively more highly orientated in the direction of the long axis of the fibres and therefore of the long axis of the tree itself. On this account tension wood should be inherently stronger in tension than normal wood. That no marked difference in tensile strength is in fact observed is explained by the incipient tension failures in tension wood as revealed by the characteristic markings on the fibre walls.

9. The abnormal longitudinal shrinkage exhibited by tension wood on drying below the fibre saturation point is not, as hitherto supposed, associated with the angle of inclination of the cellulose fibrils in the wood cell-walls. It is most probably associated with the markings in the walls of tension-wood fibres. These markings are regarded as minute, transverse cracks indicative of a stretched condition in green tension wood. The closing of innumerable cracks of this type and disposition during drying of tension wood accounts, in large measure, for the well-known abnormal longitudinal shrinkage.

ACKNOWLEDGEMENTS.

The investigation described in the foregoing paper was carried out as part of the programme of the Forest Products Research Board (Department of Scientific and Industrial Research) while the author was in receipt of a British Council Scholarship. The author wishes to express his sincere appreciation to the Department and to the Director of Forest Products Research for providing the necessary facilities at the Princes Risborough Laboratory. He wishes to thank the staff of the Laboratory for their help and co-operation at all times, and especially Messrs. B. J. Rendle and W. G. Campbell for their valuable advice, encouragement, and criticisms. He is also indebted to Mr. G. L. Franklin for assistance in preparing the material for microscopic examination, Mr. D. F. Packman for assistance with the chemical analyses, Miss C. B. Pettifor for help with the statistical analyses, and Messrs. W. R. Hutchins and W. J. Baldwin for preparing the photomicrographs.

He wishes to record his gratitude to the British Council for granting the scholarship, and for their interest throughout the course of the research.

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PLATE VI

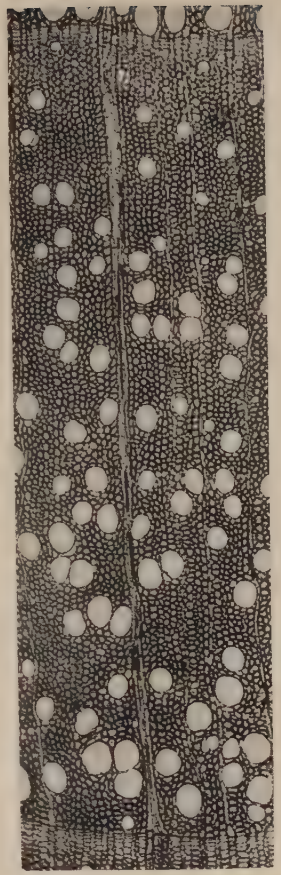

FIG. 1. Cross-section of beech tension wood (medium ring-width). (× 100.)

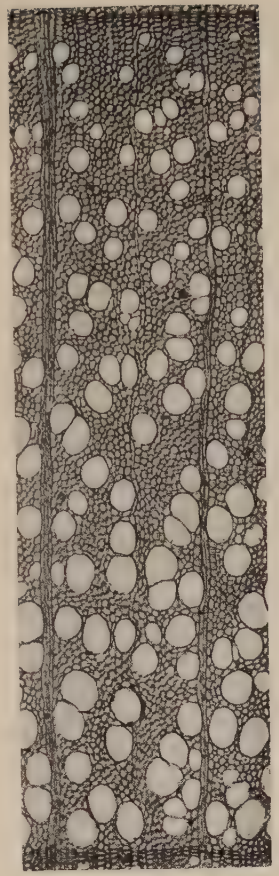

FIG. 2. Cross-section of beech normal wood (medium ring-width). (× 100.)

FIG. 3. Tension wood fibre, after treatment with chlor-zinc-iodine, showing discontinuous spiral markings. (× 500.)

FIG. 4. Normal wood fibre, after treatment with chlor-zinc-iodine. (× 500.)

FIG. 5. Tension wood fibre, after dehydration with acetone and ether, showing laminated structure of the cell wall and serrated appearance of the spiral markings. (× 500.)

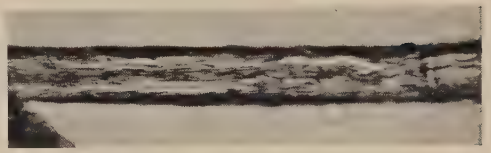

FIG. 6. Normal wood fibre, after dehydration with acetone and ether, showing laminated structure of the cell wall. (× 500.)

Fig. 7. Longitudinal section of tension wood, after chlorination and extraction with hot alcoholic monoethanolamine. In the areas marked by a circle the markings on the fibre walls can be seen to run continuously across two or three adjacent fibres. (× 250.)

PLATE VII

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BOTANICAL NAMES OF FOREST TREES

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ACCORDING to the International Rules of Nomenclature, with certain exceptions in the case of genera, the earliest name since 1753 must be accepted. During the last twenty to thirty years a great amount of investigation into early records has been carried out, with the result that some of the long-established botanical names have dropped out, earlier names having the priority. A typical case is the European Larch, *Larix europaea*, the present name of which, according to the International Rules, is *Larix decidua*.

These changes are very disturbing to the nurseryman and to the forester, who deal with commercial products; the forester is also concerned with long-term records, e.g. stock maps and compartment records in which any change in nomenclature may easily lead to confusion. Worst of all, there is no finality about the changes, because further delving into the past may at any time throw up an earlier name which must be adopted.

This state of affairs led the Forestry Commission in 1934 to issue a list of botanical names of the more important forest trees, with the instruction that these names were to be adhered to in all future departmental reports and official publications. It is not proposed to alter the Forestry Commission Standard Botanical Names, and these will continue to be used by all officers as heretofore.

For the convenience of new members of the staff as well as for information of the forestry public, this list is reproduced below. The English name is given first, then the Forestry Commission's standard botanical name, and lastly, in the third column, the latest name according to the International Rules of Nomenclature, when this differs from the Commission's nomenclature.

The Commissioners are indebted to Mr. B. J. Rendle of the Forest Products Research Laboratory, Princes Risborough, Bucks., for verifying the International Names.

Botanical Names of Forest Trees

As at 15th May 1945

English name	*Forestry Commission Standard name*	*Present name by International Rules*
	Conifers	
Scots Pine	*Pinus sylvestris* L.	
Corsican Pine	*Pinus laricio* Poir.	*P. nigra* var. *calabrica* Schneid.
Austrian Pine	*Pinus austriaca* Hoess.	*P. nigra* var. *austriaca*. Asch. et Graebn.
European Larch	*Larix europaea* DC.	*L. decidua* Mill.
Japanese Larch	*Larix leptolepis* Gord.	
Douglas Fir	*Pseudotsuga douglasii* Carr.	*P. taxifolia* Brit.
Norway Spruce	*Picea excelsa* Link	*P. abies* Karst.

English Name	*Forestry Commission Standard name*	*Present name by International Rules*
Sitka Spruce	*Picea sitchensis* Carr.	
Western Hemlock	*Tsuga heterophylla* Sarg.	
Western Red Cedar	*Thuya plicata* D. Don.	
Silver Fir	*Abies pectinata* DC.	*A. alba* Mill.
Grand Fir	*Abies grandis* Lindl.	
Lawson Cypress	*Chamaecyparis lawsoniana* Parl.	
Monterey Cypress	*Cupressus macrocarpa* Gord.	
	Broad-leaved Trees	
Ash	*Fraxinus excelsior* L.	
Beech	*Fagus sylvatica* L.	
Pedunculate Oak	*Quercus pedunculata* Ehrh.	*Q. robur* L.
Sessile Oak	*Quercus sessiliflora* Salisb.	*Q. petraea* Liebl.
Sycamore	*Acer pseudoplatanus* L.	
Silver Birch	*Betula verrucosa* Ehrh.	*B. pendula* Roth.
White Birch	*Betula pubescens* Ehrh.	
Black Italian Poplar	*Populus serotina* Hart.	*P. canadensis* var. *serotina* Rehd.
Sweet or Spanish Chestnut	*Castanea sativa* Mill.	
Common Alder	*Alnus glutinosa* Gaertn.	
Grey Alder	*Alnus incana* Moench	
Hornbeam	*Carpinus betulus* L.	
English Elm	*Ulmus campestris* L.	*U. procera* Salisb.
Wych or Scots Elm	*Ulmus montana* Stokes	*U. glabra* Huds.

SOCIETY'S AND OTHER NEWS

NINETEENTH ANNUAL GENERAL MEETING

The above meeting, held at Dartington Hall, Totnes, South Devon, received the Council's Report for years 1939 to 1945, approved the accounts for the same period, confirmed the appointments of Office-Bearers and Councillors made under the Assent of 1941 which enabled the Council to carry on without Annual General Meetings during war-time, recalled the Assent, and restored the Constitution and Rules to full operation. A motion was passed which, when confirmed at the next General Meeting of the Society, will increase the number of elected Councillors from six to ten. On a motion by Mr. Ray Bourne, the Council was directed to appoint a committee to review the Constitution and Rules of the Society in the light of recent developments, and it is probable that the committee will have been appointed and begun to function before this number of the *Journal* has been issued. Rules for awarding the Society's Medal were adopted as reported below.

THE SOCIETY'S MEDAL

The idea of a medal originated as long ago as 1928 when Mr. R. L. (now Sir Roy) Robinson, who was then President, intimated that he would present a medal to the member who should make the most outstanding contribution to forestry knowledge in the course of the year. There were no candidates for the medal in 1928 and 1929, but in 1930 an essay was submitted unsuccessfully.

Thereafter the Council decided 'that the Society award a medal from time to time to any individuals who may have rendered eminent services', and in 1931 the first three Presidents together subscribed £10 as the nucleus of a Medal Fund to provide the medals. Three trustees were appointed to hold the Medal Fund, which has been augmented from time to time by donations from successive Presidents.

In 1943, following an application by a member for an award of the medal to him, the Council drafted regulations for the award of the medal, to be submitted to the first meeting of the Society after the war. In order to be ready to proceed as soon as the regulations had been approved, the Council appointed a committee under the convenership of Professor Steven to obtain a suitable design for a bronze medal. Their design was approved and a specimen medal was received (see Plate). The designers were Miss Roberta Burnet and Miss Eileen Nicholson. The modeller was Mr. Hewan Crichton.

The regulations were duly considered at the nineteenth Annual General Meeting, and, after being amended in a few minor respects, were approved. A copy is appended. That meeting also resolved, on the recommendation of the Council, that the first award of the Society's Medal be made to Sir Roy Robinson, Chairman of the Forestry Commission and Director-General of Forestry, in recognition of his eminent services to British forestry. The medal will be formally presented to Sir Roy at the next General Meeting.

Regulations Governing the Award of the Society's Medal

The Society may from time to time award a medal to any individual who has rendered eminent services to British forestry.

The following shall be the procedure to be adopted in connexion with the award of the medal:

1. No proposal to award the medal shall be made except by a member of Council.

PLATE VIII

MEDAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

2. A member of Council desiring to propose the award of the medal shall send to the Secretary a signed motion in which he shall specify the proposed recipient and state briefly the services rendered which the mover considers to have been sufficiently eminent to justify the proposed award.

3. The Secretary shall include the motion in the agenda of the next Council Meeting.

4. The Council, on the matter being thus brought before it, shall (*a*) resolve to recommend that the Society make the proposed award, in which case the Secretary shall include the recommended motion in the agenda of the next meeting of the Society; or (*b*) postpone consideration until the next meeting of Council in order to give the mover time to bring forward further evidence in support of his motion, in which case the Secretary shall include the motion in the agenda of the next meeting of Council; or (*c*) resolve that the services rendered have not been sufficiently eminent to justify an award, in which case its decision shall be final.

5. The Society, on having a recommendation by the Council thus brought before it, shall either make the award recommended or resolve that it be not made.

24th September 1946.

EXCURSION TO DARTINGTON HALL, DEVON

The first post-war excursion, held at Dartington, South Devon, from 23rd to 26th September 1946, on the invitation of Mr. L. K. Elmhirst, Chairman of the Dartington Hall Trustees, attracted a larger attendance than any pre-war excursion. While this may have been partly due to the fact that the members had not had an opportunity of meeting since 1939, there is no doubt that the reputation of the Dartington Woods as an outstanding example of successful private forestry was the main attraction. The actual attendance was 40, but it would have been over 50 had all who enrolled been able to participate. Hitherto 20 had been considered a good turn-out.

The programme was prepared by Mr. W. E. Hiley, the Woods Manager, and many of the detailed arrangements were carried through by his assistant, Mr. R. H. Hide, to both of whom the Society is greatly indebted for the success of the excursion.

Through the kindness of the Trustees more than half of the party was housed very comfortably in the Courtyard of Dartington Hall, where everyone was made very welcome.

The chief woods and features which were seen and discussed in the course of two very interesting days are grouped below by species.

Ash

Two woods were visited.

(1) *Chasegrove Wood*

Ash was growing well with some sycamore and beech on a very good deep loam over Upper Devonian limestone. There was a dense ground flora of garlic, nettle, hemlock, and other herbs. For many years the ash from this wood had been sold for highest quality sports work. A sub-compartment planted in 1914 with ash and sycamore now showed 132 ash and 32 sycamore per acre.

The mean quarter girth at breast height of this ash at 32 years was 7¼ inches. The volume per tree was 10 cu. ft. over bark, and the volume per acre was 1,600 cu. ft. over bark (Hoppus measure).

The crop had been thinned repeatedly and a further thinning was to be done in the coming winter. Growth in height was rapid.

The treatment had favoured height rather than girth. There was a discussion on whether this was desirable in the case of ash and similar hardwoods. As price favoured girth rather than long lengths, it was thought that early and heavy thinning was indicated. About 6 to 10 annual rings per inch were believed to be the optimum rate of growth for timber quality in ash.

The price for selected butt lengths, 7–14 inches Q.G., for tennis rackets was 5 shillings per cu. ft. (Hoppus, delivered Totnes) in 1939; the present price for similar material, planked, is now about 15 shillings.

There was also a discussion on whether the sycamore—which were not of good quality—and beech should be removed where they were in any way interfering with the ash. It was urged that ash did best in a mixed crop, where humus, from such a crop, and shading of the stems were provided; and that the sycamore and beech should be retained unless damaging really good ash.

(2) *Staverton Ford Plantation*

Some strong natural regeneration of ash was seen, adjoining the conifers and oak planted in 1928–32. A considerable number of the ash saplings were forked, due to the ash bud moth and other causes. There were about 500 to 600 trees per acre.

Opinions were invited on whether the forked trees should be pruned or removed in the course of thinning. As forking tended to recur, the majority of those present favoured removing the forked trees in the course of thinning.

Oak

Newground Plantation

The area was planted with oak after the Napoleonic Wars, about 120 or more years ago. It had been cultivated ground before this planting up. The soil was a stiff clay loam, digging like a loam but ploughing like a clay. The growth of the oak was slow, perhaps due to poor drainage, but the timber was of good quality. This contrasted with oak from dry stony ground in the west of England, which was apt to be full of shakes and of low value. (Some Dartington Hall oak was fit for barrel staves, it was mentioned.)

This wood had been thinned twice since 1935. A suggestion was made that ash might be favoured in the next crop on this ground. The consensus of opinion was that the soil was too heavy for ash.

Cod Wood

A large area of oak coppice was seen on steep ground where extraction was difficult and special roads were under construction. This coppice was to be replaced by planted conifers because of the poor quality and value of the oak, much of which was selling as firewood.

A mechanical excavator had been used in the road construction. For the first few days the cost of this machine's work was 3·5 shillings per running yard, but heavy oak stumps subsequently delayed it and, after paying for the time taken to get the machine to and from the site of the work, the cost came to about 10 shillings per running yard.

Portable circular saw benches, driven by oil engines, were being used to cut the firewood. Cleft oak stakes, 5 ft. 6 in. long, with a face 3½ inches and up, were being made from 5 ft. 6 in. straight lengths of oak, 4–8 inches in diameter. Their value was about 1·5 shillings each in 1939 and about 3·5 shillings each in 1946.

Larch

In a preliminary general talk on larch it was mentioned that at Dartington and in other parts of southern England the well-known hybrid larch (*L. eurolepis*) had not grown well.

It was slower than Japanese larch, though perhaps rather straighter. With European larch there had been some die-back at Dartington, which might have been associated with bad nursery stock.

The system called 'stroll' planting was explained. 'Stroll' was a local name for hay when raked into long rows. The same name was applied by analogy to the lop and top of a previous tree crop, such as coppice oak, when collected into windrows or 'strolls', 10 or 12 feet apart. By retaining these rows the cost of burning them was avoided, and conifers planted on each side of the rows seemed to like them. The conifer roots ran under the pegged-down brushwood which rotted and made humus. Such oak often grew over whortleberry, on a very acid soil. (The oak coppice used to be made into charcoal and extracted on donkeys.) Japanese larch and Douglas fir were planted 6 ft.×6 ft., and European larch 5 ft.×5 ft. or 5½ ft.×5½ ft.

Luckdon, North Bovey. 60 acres.

An interesting larch wood of 50 acres, planted at 800–1,200 feet elevation about 1904 on farm-land, was visited. (It has been described in the *Quarterly Journal of Forestry*, xxxiv. 127, July 1940.) It was of 1st and 2nd quality on the lower portions of the site, and of poorer quality on the upper portions, at about 1,200 feet, on the north-east slope of Dartmoor.

It had been thinned heavily in the war of 1939–45. Of 4,000 cu. ft. total volume (Hoppus, standing), 2,500 had been taken and 1,500 left. 380 out of 510 trees had been felled.

Many windfalls had been feared, but they had not occurred. The soil was granitic and the timber sound. The trees had not been pruned. The growth rate of the timber was about 8 rings per inch. The crown response to the opening up had been good, especially in the upper, poorer parts of the wood.

There were still 130 larch trees per acre and it was proposed to underplant with Douglas fir, but several visitors felt sure one could start Douglas under such a crop but not get it through. In Scotland such a larch crop would be much reduced in trees per acre before underplanting; and in the Forest of Dean the custom was to leave only 40 trees per acre and avoid planting within 8 feet of the big trees.

Some visitors were against underplanting with Douglas fir or *Thuya* because of the risk of disease. *Abies grandis* was suggested. The danger of concealed heart rot in such larch as were now left in this wood was mentioned.

As a result of the discussion the idea taking shape was to reduce the crop to 40 trees per acre and underplant with Douglas fir, 6 ft.×6 ft., but not within 10 feet of the standing larch.

Sitka Spruce

Sitka spruce planted in 1928 were seen in North Wood and in Staverton Ford Plantation. In the former case the spruce was in alternate lines with Douglas fir. Some visitors thought such ground was too soft and liable to wind blow for Douglas. Norway spruce was suggested as preferable, the Sitka being reserved for poorer ground and exposed conditions.

There was a discussion on whether the major aim of the future should be quantity or quality of timber. The value of sheer bulk for box-making and such uses was argued by one side but others thought differently. The difficulty of forecasting future demands was recognized.

After seeing the Sitka spruce of 1928 in Staverton Ford the visitors were asked their opinion on delaying thinnings in such a crop, to get ladder poles and pit-props. One reply was that delay might lead to severe wind damage: it was necessary to ask:

(1) Would the crowns recover, if left any longer?

(2) Would the trees blow over after the eventual thinning?

The majority favoured caution in delaying thinning for the sake of intermediate yields.

Douglas Fir

A good stand of Douglas fir, dating from 1900, was seen in North Wood. The timber produced in heavy thinning of this stand had been very sound and had sold well. Against wind blow the best safeguard was thought to be strong, large, individual crowns.

A visitor from Scotland spoke of the damage there by the breaking of Douglas fir stems when felled on uneven ground.

Some natural regeneration of Douglas fir and other species was seen in North Wood; but the weed growth, including brambles up to 6 feet high, followed by bracken, was reported as costing so much to clear or check that planting was cheaper in certain circumstances.

An interesting mixed plantation area in North Wood, including Douglas fir and stands of various species ranging between 25 and 43 years of age, was discussed. It was hoped to convert this area to a selection forest. One authority on financial calculations remarked that they seemed to point usually either to reaping a whole crop at the pole stage or to growing a small number of trees per acre to a larger size. So there was something to be said for the irregular, uneven-aged forest which provided both these crops. In Switzerland such a forest was gone over once in every 5 or 6 years by selection felling.

A crop of very promising Douglas fir about 40 years old, heavily thinned, was also seen in North Wood, and was remarkable as having been pruned to a great height, relatively late in life, for amenity and interest. It appeared as if the same external result and a much greater depth of clear timber in the bole would have been obtained by suitable pruning earlier in the life of the crop.

Various Exotic Conifers

A series of interesting plantations of exotics was seen in North Wood.

(1) *Pinus radiata* of 1934 was growing very fast (average height 26·8 feet in 1943–4) but was reported as liable to be killed by frost (even when 30 feet high in the colder parts of Britain); also as growing very fast in the crown before the roots had taken hold and often requiring staking when young. A sample tree had been felled. It measured 39 feet high, had grown 11 ft. 2 in. in the previous 3 years, and had a volume to 3 inches diameter of 3·4 cu. ft. Hoppus. The habit of the species in Devon was much less straight and clean than in South Africa. It grew specially well in west Cornwall.

The following sample plot data were recorded in 1943–4, at 10 years of age:

(*Per acre*)

	No. of trees	*Q.G.B.H.*	*Average height*	*Total vol. O.B.*
Remaining . .	1,070	3·6 in.	27 ft.	1,330 cu. ft. Hoppus
Thinning (in 1943) .	332	3·3 in.	26 ft.	333 „ „
Total . . .	1,402	..	..	1,663 „ „

(2) *Sequoia sempervirens* of 1934. A sample tree had been felled. It measured 44 feet high, 7 inches quarter girth overbark at 4 ft. 3 in., and cubed 6·93 feet (Hoppus). It had been growing about 3 feet per annum.

The following sample plot data were recorded in 1943–4, at 10 years of age:

(*Per acre*)

	No. of trees	*Q.G.B.H.*	*Average height*	*Total vol. O.B.*
Remaining . .	1,319	3·3 in.	28 ft.	1,434 cu. ft. Hoppus
Thinning (in 1943–4)	426	2·9 in.	25 ft.	302 „ „
Total . . .	1,745	...	..	1,736 „ „

The thinnings of this species were reported as excellent for bean sticks and pergolas because so durable and retentive of their bark.

It was difficult to get satisfactory seed from America. Apparently only certain mother-trees produced such seed. It coppiced freely and could be grown from cuttings from coppice or stem shoots. (Some natural regeneration of the species was reported from Benmore, Scotland.)

There was a wide variety of opinion on how this stand should be thinned.

(3) Hemlock (*Tsuga heterophylla*) of 1933 and 1934. A sample plot measured in 1945–6 at 13 years old showed, per acre:

	No. of trees	*Q.G.B.H.*	*Average height*	*Total vol. to 3 in. top. O.B. Hoppus ft.*
Remaining . .	1,412	3¼ in.	33 ft.	1,631
Thinning . . .	184	2½ in.	30 ft.	94
Total . . .	1,596	..	..	1,725

An authority on pit-props thought this species, planted 5 ft. × 5 ft., was the best producer of pit-props in Great Britain. A visitor said that in his experience hemlock grown in Britain was apt to be punky sometimes.

THE DARTINGTON HALL LTD., SAW-MILL, SEASONING KILNS, AND WOOD WORKSHOPS

This commercial saw-mill, which is independent of the Woodlands Department, is situated at Shinners Bridge, Dartington, and absorbs about 140,000 cu. ft. of round timber per annum. The average recovery in the mill was reported to be 70 per cent. (sawn timber from Hoppus volume of log). The individual logs were tagged with soft metal and followed through so that their outturn was known, at least by batches. The main bandsaw could take logs up to 4 ft. 9 in. diameter, and there were two band resaws, a pendulum cross-cut and a reciprocating cross-cut saw; also a Danarm portable saw.

Steam was generated from off-cuts and steam-blown sawdust. Wood ash was produced and sold.

The kilns were 'Esavian'. The manager remarked that their elm took longer to dry than the Princes Risborough schedule estimated, because their elm went into the kilns at a higher initial moisture content than that assumed at Princes Risborough.

Coffin boards and prefabricated untreated wooden paling sections, both of elm, were being made. In the turnery shop some handsome bowls of tropical woods were being produced.

THE ECONOMICS OF FORESTRY: WOODLANDS ACCOUNTING SERVICE

THE following notice and invitation is published at the request of the Department of Forestry, University of Oxford. Whether costing should be by crops or by operations, or sometimes the one, for certain purposes, sometimes the other, for different purposes, is an issue on which comment would be welcome, no doubt, if sent to the Forest Economist, Oxford.

'The Economics of Forestry

'The Department of Forestry at Oxford University is at present carrying out research on the economic problems of woodlands on private estates. One of the many lines of approach is the building up of cost-of-production data on a wide range of forestry operations. From time to time it is intended to discuss in reports the factors influencing the

range of costs on individual estates and plantations. A certain amount of standardization in the definition of each operation is essential if best use is to be made of the comparisons. With this in view a pamphlet—*The Business Aspect of Forestry*—has been prepared to define the various headings of costs, with accounting forms to show the type of information which is required if comprehensive costs are going to be kept on private estates. The stage of development, scale of operation, and degree of intensity of the forestry productions make it difficult to devise a scheme which will be suitable for all estates and for all purposes. It is thought, however, that the scheme as outlined in the pamphlet can be adapted to the requirements of any given estate, although many of the individual headings or sections may not relate to any one property.

'In addition to providing a basis for costs investigation, the scheme has been designed to facilitate the production of the summarized details for the "Schedule D" of the Commissioners of Inland Revenue and for the "Forms of Account" of the Forestry Commission; annual profit and loss accounts of estate departments such as the nursery, and the saw-mill; and a link with the working plan of the estate.

'The Forest Economist at the Department of Forestry, Parks Road, Oxford, would welcome any co-operation in the supply of economic information on private woodlands, and would be prepared to do the essential work of analysis of time sheets and other fundamental accounts for a limited number of estates. The source of data would be treated in confidence. Copies of the above pamphlet, which indicates in detail the type of information required for the economic research, will be sent on application.'

'*The Business Aspect of Forestry* (*June 1946*)

'The system of accounts which is outlined in the accompanying explanatory notes is designed primarily to meet the requirements of a Woodlands Accounting Service which the Imperial Forestry Institute is developing in order to obtain the data essential for the comprehensive economic study of current forestry problems. Briefly the system seeks to obtain costings data from a variety of estates—covering a variety of environment and species of tree—on a standardised pattern. Through a standardisation of the detail it should be possible to make comparative reports for those estate owners who co-operate with the Institute. The Provincial Agricultural Economists have, for more than two decades, been providing a similar kind of service for the farmers who co-operate in the Farm Management, the Milk Investigation and other enterprise cost surveys.

'The estimation of costs and other economic features of forestry have their own peculiarities and difficulties but it seems worth while to start analysing in some detail the more common economic problems. The development of an adequate and comprehensive system of cost accounting for forestry is one of the most fundamental approaches to such problems. It is for this purpose that the costing aspect is emphasised in the accounting system although, as indicated in the notes, other important objectives are also borne in mind. The system, as outlined, represents a compromise on the amount of details and on the amount of clerical work that can reasonably be expected from an estate office. The need for a large number of separate columns or categories of entry arises from the complex nature of forest operations but it can be pointed out that for some of the forms the entries will be spread over a number of years and that for most columns there will only need to be one or two summarised entries.

'The preparation of the individual accounts will be greatly facilitated if—as is the usual practice—time sheets are kept by the individual workers on the estate, and if the materials and other items have been in any case recorded elsewhere in existing estate accounts. It can thus be claimed that the system does not add greatly to the existing clerical work, and

even where it does add, it seems that there are many sound reasons for treating the woodlands as a separate department and giving more details to help in the maintenance of efficient management. Woodlands receive special taxation concessions which may make them an attractive financial enterprise on many estates and it is worth while to keep appropriate records. As the woodland area of Britain is still very largely on private estates and since the dedication policy makes provision for the revision each five years of the scale of financial grants on the basis of ascertained costs there is need to prepare a large body of independent costings information.

'It has been found through visiting private estates that many owners would welcome some standard system which would enable some of their results to be compared with those of other estates and thus help in the management of their woodlands. Too often the woodland accounts have been prepared to meet the bare requirement of the taxation schedule or to show—in a very broad way—how the money has been accounted for. Existing systems of financial accounts on estates can meet the costings account requirements by including all essential details. The degree of detail can be inferred from the explanatory notes and the attached account headings. Provided the detail is available it will be possible to analyse out the result in the proposed standard way; and in this analysis work the economist at the Institute is prepared to help to the maximum extent.

'Although the data from individual estates co-operating in the scheme are treated in confidence it is proposed to discuss in an annual report the factors influencing the range of costs on a wide number of individual operations. It is thereby hoped that an added interest will be given to woodland management and that, through this interest, a further stimulus may be given to its efficiency.'

REVIEWS

Forest Soils and Forest Growth. By S. A. Wilde. Waltham, Mass., The Chronica Botanica Co.; London, W.C. 2, Wm. Dawson & Sons, Ltd. 1946. Price 5 dollars.

Review by H. M. Steven

THIS book is volume xviii of 'A New Series of Plant Science Books', edited by Dr. Frans Verdoorn. Dr. Wilde is Associate Professor of Soils at the University of Wisconsin, and has a considerable volume of published work on different aspects of forest soils.

The following is a general outline of his treatment of the subject. Chapter I consists of a brief historical survey, the author's definition of a forest soil, and a discussion of the importance of forest soils in silviculture. He rightly notes the importance and difficulty of the management of forest nursery soils, and that the importance of soil characteristics is most obvious in reafforestation, and one might add still more so in afforestation. Chapter II deals briefly with the genesis of forest soils on the classical lines first propounded by Dokuchaev. The author emphasizes the importance of the forest to soil development, but one would have liked to see this more fully developed, because it is the very heart both of the subject and its application to silvicultural technique. Chapters III and IV deal with the genetic soil groups of the world. The author claims that a classification of soils on a genetic basis provides the best framework on which to base the application of the same silvicultural policies and methods. In this he follows Stremme and others in another connexion. The reviewer agrees whole-heartedly with the view that the genetic soil group should be an important part of such a classification, but he is of the opinion that it is an over-simplification to hold that it should be the sole basis. From what the author says elsewhere he will probably agree with this view. The author's genetic groupings have points of interest. Chapter III deals with 'Upland Soils' in contradistinction to 'Hydromorphic and Embryonic Soils' in Chapter IV. The first includes podsolized soils, grood or nut-structured prairie-forest soils, melanized soils, a term coined by the author for brown earths and similar soils, and lateritic soils. The second includes the gley and organic soils. The word 'Upland' in this sense is perhaps not very happy, because many of these soils occur on lowland sites, and gley and organic soils are often upland soils. In most of the sub-groups the author gives profile descriptions of American examples, in some instances with analytical data. He also lists the principal associated forest species in North America, Europe, and Asia, and gives some observations on seed production and ease of regeneration on the different types. Chapter V is entitled 'Forest Cover, its Biological Structure and its Relation to Environment': a number of topics, such as the relation of forest vegetation to soils, succession, and soil development, are discussed briefly. In the next two chapters the author deals with the physical and chemical properties of forest soils in a realistic way and brings together the existing information, unfortunately still meagre, on the relationship of these properties to silvicultural technique. Chapter VIII gives a useful summary of the knowledge about the organisms of forest soils, but Rayner's work on mycorrhizae in this country is not given adequate treatment. The author then deals with forest humus, and the importance of humus in nursery soils is stressed. Chapter X is interesting; it deals with soil-forest types, that is, the linking of selected forest types to their associated soil types. The author draws some of his examples from European types. The next chapter deals with forest soil survey; it does not go into this subject in detail,

and something more intensive is called for in this country. Chapter XII discusses soils and tree-planting. There is a good deal of description of methods of planting in this chapter, with only limited discussion of these in relation to the soil. There has probably been more work done on this subject in this country than in America. The next chapter is on amelioration; this is an important subject for us in Britain. The author, however, has nothing new to say on the subject, and in many respects there is a better appreciation here of the necessary correlation of methods and soils, while methods appear to be more developed here than in America. One turns to the next chapter, entitled 'Silvicultural Cuttings in Relation to Soils', with expectation, because this important subject is still undeveloped. The author briefly summarizes the principal silvicultural techniques to secure natural regeneration, but the effect of soil on the selection of these, and the effect of these techniques on soil development or retrogression, is not developed to any extent. The basic data are still very fragmentary, but something more might have been attempted from general principles. The same criticism applies to the chapter on the productivity of forest soils and forest management; the data are not yet available to provide the correlation.

The remaining five chapters deal with forest nurseries, and the author is to be congratulated on giving so much space to this important subject. Many topics are dealt with, from the selection of nursery sites to the use of composts and parasite control. Perhaps the most interesting from the British point of view is the author's discussion of the problem of the maintenance of fertility. The author had already published work on the soil nutrient status, &c., of virgin soils under productive forest stands as an approach to determine the nutrient level necessary in nurseries, and the best balance of nutrients. This is worthy of attention in this country. On the other hand, some recent work in this country suggests that the microbiological condition of the soil may be a cause of decline in fertility, apart from exhaustion of nutrients.

This outline should indicate to the reader the scope and salient characteristics of the book. It will be more useful to the university student in this country than many American books, because the author has not drawn his examples solely from America. Much useful information has been brought together and attractively presented. It calls for some background knowledge of both soils and silviculture, but it can also be recommended to the serving officer if he is of a fairly recent vintage, or has followed the developments of soil science sufficiently to know the terminology and methods employed. There is an extensive bibliography, and one important feature of the book is the extent to which Russian literature, both soil and silviculture, has been drawn upon. The book is illustrated by a number of plates as well as attractive and informative diagrams in the text. The publishers are to be congratulated on the production.

Forests and Forestry in Great Britain. By W. L. Taylor. Crosby Lockwood & Son, Ltd. Price 12*s.* 6*d.*

Review by G. B. Ryle

THE Forestry Commission came into active life in 1919 and this is the first book to be written by a member of its senior staff who began as a Divisional Officer and reached Commissioner's rank via the successive posts of Land Acquisition Officer, Deputy Surveyor of the Forest of Dean, and Assistant Commissioner for England and Wales. During the first World War and for the first part of the second World War he was engaged in the Timber Supply Departments. He has thus had an abnormal opportunity to study British forestry from a very wide angle. It is a common but unfortunately a seemingly inevitable fault of many Government Forest Services that the technical officers are so heavily

burdened by the daily rush of their official duties that they fail and finally become unable to see the wood for the trees. W. L. Taylor has successfully avoided this fault and has produced a book which is both readable and broad in its outlook: his forests are living complexes, not mere masses of trees. Those who can attain the standard of the ideal forest officer whom he envisages (Chap. III) will likewise get out of the rut.

This is not a text-book of modern silvicultural technique, nor is it one of panic that the day of ultimate timber famine is nigh, but it is just an honest-to-goodness story of what British forestry has been from early historical times up to a few days before the final conquest of Germany in 1945; and an equally honest recommendation as to what British forestry should be—nay, must be—in the future if we are to retain our position as a self-reliant front-line nation. It has been published, too, almost contemporaneously with the Minister of Agriculture's announcement on the country's immediate forest policy, and it should go a good way to create in the minds of the public that feeling of confidence, sympathy, and support which will be so essential to get this new and bold policy safely launched.

That a small island kingdom with a reputed figure of only 5 per cent. of its total area under forest should yet contain sixteen million acres of rough uncultivated land, much of which was long ago forest land, is a state of affairs shocking to all who are 'land-minded'. The general state of neglect of that 5 per cent. of forest land (which has been oft quoted in forest text-books but is a very hypothetical figure) is an even more shocking fact to all who have been trying to produce essential timber requirements from these woods during the past six years of war. How very much easier in man and machinery power would the timber-supply job have been if these woods had been reasonably managed and properly stocked: what a much smaller acreage we should have had to devastate to yield the same bulk of goods, and what much better quality goods we could have produced.

The British climate and soil are capable of growing nearly all the softwood species which we require for our timber-consuming industries, but it can hardly be agreed (page 81) that nearly all the hardwood species usually imported are capable of development in this country.

Despite a sane desire to re-create those rural industries which in the past were capable of economical utilization of all kinds of 'minor forest products', the author wisely admits that the coppice woods and the old coppice with standards system are doomed. Many of them have already been cleared for war requirements or had earlier degenerated to utter scrub-waste. Mr. Taylor suggests that more of the oak coppices of the west of England, the Welsh valleys, and the west of Scotland should have been cut for pitwood during the past six years. Surely in 1945 there are not many suitable woods of such class still left standing?

Speaking of timber production in two wars of this generation, praise is rightly given to military and overseas forestry contingents, and to the women's organizations, which did such magnificent work in our woods and saw-mills; but the ordinary British workman was, after all, the backbone of the Home Timber Production Department, and has had a very poor 'press' everywhere. Nor can we agree that this last war has seen a concentration of timber devastation in 'the best of the hardwood stands to the relative exclusion of the inferior but utilizable qualities'. It is true that many of the best woods have gone, but this was inevitable in a total war when timber goods were needed urgently and labour was scarce. However, immense inroads have been made into the really bad hardwood forests, areas which would be unmarketable in peace-time. This applies both to privately owned woods and to big hardwood stands in the State forests in the Dean and elsewhere.

These are but small criticisms on minor points of a book which covers a huge field of

abnormally digestible matter, written by one who obviously loves his forests and loves the denizens in them; all the denizens, that is to say, with the exception of the rabbit. The rabbit he hates with a deadly hatred.

The selection of photographic plates, which, owing to war-time restrictions, could not be reproduced beside the relative text, is a very happy one.

Über die Bedingungen der Mykorrhizabildung bei Kiefer und Fichte. By Erik Björkman. Pp. 190, with 45 tables, 62 figs., and English summary. Symb. Bot. Ups., vi. 2. 1940.

Review by I. Levisohn

Björkman starts his investigations with field studies. He examines a number (13) of representative Swedish forest communities, analyses their soil in respect to profile, humus content, mineral contents, and pH values, makes statistics of the vegetation, including the higher fungi, and puts on record the radiation intensities in the localities in question. Frequency and types of mycorrhizal infection in pine and spruce are studied and recorded in a number of tables and photomicrographs of excellent quality. This investigation gives much specialized information about Swedish forest communities, but it gives hardly any clue as to the role of environmental factors in determining frequency and structure of mycorrhizal infection. The only conclusion drawn by the author is that mycorrhizal development is generally high in raw-humus, less high in typical mull soils, and very scarce on freshly drained moors. On reading this chapter, occupying 60 pages, one is greatly impressed by the amount of detailed statistical work involved, but rather disappointed that these investigations do not throw much light on mycorrhizal problems.

The parts dealing with the grouping of mycorrhizal types in pine and spruce invite criticism. The author's classification—largely agreeing with that of Melin—is based on certain histological structures. According to him, hypertrophy of the cortical cells and the presence of the Hartig net are characteristic of a 'mycorrhiza'. Associations that do not show both these structural features are 'pseudomycorrhizas'. It is generally thought and recorded that hypertrophy of the cortical cells—either by enlargement of individual cells or by increase in number—is a constant feature of true mycorrhizas, and that, in general, pseudomycorrhizas do not show this hypertrophy. It is unsafe, however, to draw the conclusion that the reactions of the root as shown by these histological structures are an infallible guide as to the effect on the health of the host plant. A classification of this kind might be serviceable for certain descriptive purposes, but is not very satisfactory when recording correlations between growth and mycorrhiza-formation, since types described as 'mycorrhizas' may conceal true mycorrhizas as well as parasitic infections. Special difficulty arises in analysing and attempting to value the forms concealed in 'mycorrhizal' type *A*. According to the author's classification, this 'mycorrhizal' type *A* in pine can be of the ectotrophic as well as of the 'ectendotrophic' form (cf. Melin, 1923). In the latter, the hyphae extend between the cortical cells, penetrate into them, and fill them out, a mantle being absent in many cases. Recent investigations with forest and nursery soils in this country (M. C. Rayner and I. Levisohn, unpublished) point to the fact that the association called by the Swedish school 'ectendotrophic' type is not a true mycorrhiza but a pseudomycorrhizal infection in the physiological sense, the fungus showing more or less parasitical tendencies. The author is not unaware that this ectendotrophic infection might be parasitic since he remarks in the summary (p. 173): 'Ektendotrophe Mykorrhiza mit einem dünnen Hyphenmantel, aber dicken Hartigschen Netzwerk und einer kräftigen

intrazellularen Infektion (der Pilz ist wahrscheinlich mehr oder weniger parasitisch) wurde vorzugsweise bei ziemlich schwachen Pflanzen . . . angetroffen', but as Björkman classifies the types exclusively according to structural features, not taking into account the physiological behaviour, he groups this form of infection under mycorrhizal type *A*. A case described on p. 20 illustrates how confusing and even misleading this classification is. Here the discrepancy between his interpretation of the 'ectendotrophic' form as being a mycorrhizal association and the recent interpretation mentioned above, putting it into the category of a pseudomycorrhiza, becomes rather significant. Fig. 2 (p. 20) shows a 'vigorous' development of 'mycorrhiza' on a very poor pine plant, 30 years old, 18 cm. in height. 'Man beachte die kräftige Mykorrhizabildung bei schlechtem Wachstum der Pflanze.' From this remark one either gets the impression that without the presence of these (beneficial) mycorrhizas the plant would not have survived at all, or one is duly surprised at this vigorous mycorrhizal development present on such an extremely poor specimen. But a photomicrograph of these clusters of 'mycorrhizas' (Fig. 3) shows that these are actually not true mycorrhizas, since they are irregular in diameter and do not exhibit real dichotomous forking, symptoms which on pine grown in this country are invariably indicative of the presence of a parasitic infection of the 'ectendotrophic' type which Björkman groups as a 'mycorrhiza'. One may assume that the section of an ectendotrophic mycorrhiza of pine, Fig. 5 (p. 22), showing deep intracellular infection and an abortive mantle, is a section of one of the short roots pictured in Fig. 3. Hence it is actually not surprising that the poorly growing pine (Fig. 2) shows such vigorous development of 'mycorrhizas'!

Part II of Björkman's work is concerned with experiments in soil- and sand-cultures, part of the latter being pure cultures. The various types of humus used in the soil-cultures were untreated, supplied with a complete nutrient solution, or with a nutrient solution defective in certain elements. In an additional series the plants were exposed to various intensities of radiation. The experiments were originally designed to test Hatch's hypothesis that mycorrhizal development takes place when the inner concentration in the plant of one or more of the elements N, P, K, or Ca is very low. This hypothesis as such was not confirmed by Björkman's experiments.

The result of his experimental research was that light is the factor of 'paramount importance' in determining mycorrhiza formation, the other two dominating factors being available N and P. In very low radiation intensity, mycorrhizas are only formed with difficulty; a certain light-intensity is required in order to form mycorrhizas, the degree of intensity depending on the quality of the substrate. Serious deficiency of available N or P, as well as abundance of available N and P, in the soil substrate influence mycorrhiza-formation adversely. When N is available in large quantities, mycorrhizas develop freely if the amount of available P is low and radiation intensity high; similarly when P content is high, mycorrhizal development is favoured only by a low N concentration. When analysing the recorded correlation between these factors (radiation intensity, available N, and available P) and mycorrhiza-formation, we are confronted, in a number of cases, with some difficulties which have already been pointed out, arising from Björkman's classification of mycorrhizal types. The incidence of the 'mycorrhizal' types *A* and *B* (grouped together in many of the tables and graphs) hardly gives any clue to the percentage of true mycorrhizas and the percentage of the 'ectendotrophic' form which, in this country at least, has proved to be more or less pathogenic.

Björkman's theory of the mycorrhizal habit is as follows: Mycorrhizas are formed when the host plant produces a certain surplus of soluble carbohydrates. This surplus and its amount is determined by the carbohydrate/proteid ratio. Where N and P are abundant

more proteids and less carbohydrates will be formed, and as there is little present to 'attract' the fungus, mycorrhiza-formation will be absent or infrequent. But when photosynthesis is rapid and a shortage of N or P is present, the synthesis of proteids will slow down and carbohydrates will pile up, leading to free mycorrhiza-formation. If, however, the lack of N, or particularly of P, is serious, the process of assimilation and thus of carbohydrate-formation is inhibited.

According to this theory, the mycorrhizal fungi 'do not enter the roots unless these contain a certain amount of soluble carbodydrates'; but how does the mycelium 'know' where to find it? Do the roots of the host plant indicate to the fungus that a surplus of sugar is present by exuding a certain substance, or do the roots without much sugar-content excrete a substance inhibiting the mycelium from penetrating the cortex? Much research on this side of the problem will be necessary for a clear picture of the mycorrhizal habit.

The Identification of Conifers. By A. Bruce Jackson. Edward Arnold & Co., London. Price 9*s.* net.

Review by E. V. Laing

THERE has for long been a demand for a small compact handbook for the ready identification of our coniferous trees. The present publication will be welcomed by the many who like to put names on the numerous conifers to be met with in this country.

The writing of such a book is not easy. There is no simple, reliable route to the identification of a conifer. It is impossible to embody in a key all the characters which mark a species, and, more especially, the variations which may exist in a species. The author of this book, for instance, figures the Scots pine as having reflexed bud scales, but gives it in the key as having adpressed scales. Both conditions exist in the field, and the student would not always accordingly find the key in this book helpful for even such a common tree as the Scots pine.

Probably because of its variability—the Hybrid larch is omitted from the *Larix* key. This is a pity, because this tree is so widely used in afforestation schemes. Some attempt should have been made to include it.

Some statements in the book are, though not important, somewhat misleading. It is said, for instance, under the general characters of the genus *Larix*, that all larch female flowers have rosy bracts. What about the Japanese larch and the green-flowered European larch so frequently found in our own plantations?

It is unfortunate that technical terms are employed in the keys without a glossary having been included in the book. The absence of a glossary prevents the book from having the wide appeal that it might have. The layman, or even the forester who has studied his botany some time in the distant past, will be often at a loss to follow the keys. This omission might be remedied in future editions.

Nevertheless, despite weaknesses, the book will prove useful. There are interesting notes on most species and the text-figures are clear and instructive.

The Pruning of Trees and Shrubs. By W. Dallimore, I.S.O., V.M.H. Printed for Dulau & Co., Oxford, and distributed by Blackwell & Mott, Ltd. Price 7*s.* 6*d.* net.

Review by H. A. Cox

THIS excellent little book, first published in 1926, has behind it sound technical knowledge and a wide experience gained by the author in a very fine training school—The Royal Botanic Gardens, Kew. Its appearance at a time when shrub-growers and arbori-

culturists are faced with the task of renovating gardens and collections of specimen trees which have perforce suffered from the unavoidable neglect of the past seven years is most opportune. It should be read particularly by all students aspiring to a sound knowledge of silviculture, for the technique of pruning and the risks attendant upon the omission to remove dead wood and to treat wounds resulting from wind and snow break or other accidents are fully and simply explained. It includes instructions for the correct treatment of many genera of shrubs and woody climbers and is therefore an invaluable reference book for everyone engaged in the maintenance of public parks, nurseries, and pleasure gardens. The illustrations are good, but might with advantage have been increased in number even if such a course had involved an advance in the price of the book.

NOTICES

Publications of the Empire Forestry Association

THE *Empire Forestry Journal* has become the *Empire Forestry Review* from the first number of 1946, Vol. 25, No. 1. It goes from strength to strength and is a very valuable link between foresters throughout the British Empire. With forestry at last coming into its own in Great Britain the *Empire Forestry Review* is giving increased attention to temperate forestry, in addition to maintaining a high standard on tropical forestry. In the first number of 1946, of 12 major articles 4 deal with the tropics and 8 are concerned with temperate regions or world forestry (F.A.O. activities). Of special merit and interest are three articles on Canadian forestry, including a summary and a review of the Sloan Commission Report on British Columbia, two articles on forestry in the British Zone of Germany, and an excellent article on the post-war forest position in Burma, by A. N. Barker, produced under and dealing with difficulties which only those who know the facts can appreciate.

A new enlarged and improved (1946) edition of the *Empire Forestry Handbook* has been produced. It is an invaluable compendium of information on forestry, forest research, the forest services, the commercial timbers, &c., of the British Empire in particular and also in less detail of practically the whole world. The lists of botanical and standard names of over 250 hardwoods and 70 softwoods imported into Britain, with their botanical families and weights per cubic foot, are a great asset. The handbook is obtainable at 10*s.* from the Editor-Secretary, Empire Forestry Association, at The Royal Empire Society, Northumberland Avenue, London, W.C.2, from whom also the terms of membership of the Association can be obtained.

Publications of the Food and Agriculture Organization of the United Nations

A LETTER dated 19th December 1946 has been received from M. Marcel Leloup, Director of Forests and Forest Products, Washington, D.C., proposing exchange arrangements between F.A.O. and *Forestry* for appropriate publications of mutual interest. The proposal has been warmly welcomed and exchange has been agreed to. The first reports and bulletins from F.A.O. have begun to arrive. These are preliminary reports of great interest. A more detailed report dated 15th August 1946, issued after the Copenhagen Conference, is awaited and will be reviewed in the next number of *Forestry*. It deals with the World Situation 1937–46 in Forestry and Forest Products. The present acute scarcity of wood in Great Britain and the shortages existing or threatened in other countries point plainly to past neglect and the great future before forestry. The crux appears to be that ample wood can be produced on a sustained yield basis if sound forestry is extended as widely and rapidly as possible to meet the growing world demand.

Publications of the Timber Development Association, 75 Cannon St., London, E.C.4

THE more active policy which this Association has followed in 1945 and 1946 has produced a growing number of very useful booklets and leaflets with a wide circulation. Much of the information is drawn with due acknowledgements from the publications of the Forest Products Research Laboratory, Princes Risborough. The booklets are well

arranged and excellently illustrated. It is a welcome sign of enlightened policy that the timber trade of Great Britain, which finances and directs the Association, has made possible these publications. The trade and the staff concerned are to be congratulated on the progress made in educating the suppliers and users of wood in its proper use.

Much of the emphasis is naturally on utilization, but there is some attention to supplies This should lead on logically to forestry and the growing of the supplies essential to the timber trade of Great Britain and the rest of the world. It is obviously desirable that foresters should be familiar with the uses made of the trees they grow, and the reactions of the customers to whom they sell; and that the timber trade and consumers of wood should understand the case for sound forestry.

A list of publications is available from the Association. Among recent booklets three of special merit deal with *Timber Pests* (fungi and insects), *Timber Preservation*, and *Timber Seasoning*. These and other booklets are issued free to members of the Association, timber consumers and students, exhibitions, and a wide public not reached by any other agency In 1945 some 60,000 were distributed. This figure and the fact that the Association was sponsoring in 1946 a three-year course in timber technology in twenty-six of the chief cities and towns of Great Britain are a measure of the efforts being made.

In addition to this publishing and educational work the Association has also active departments dealing with (1) statistics and information, and (2) timber utilization. The last of these answers technical inquiries, and to it has been added recently a constructional research directorate which is expected to produce text-books and handbooks in due course

The Wood from the Trees. By Richard Jefferies. The Pilot Press Ltd., 45 Great Russell St., London, W.C.1. March 1945. Price 9*s.* 6*d.*

THE great merit of this vigorous book is that it presents some of the main facts about wood in a striking fashion likely to attract general readers as distinct from forester and the timber trade. On the utilization side, especially some of its modern aspects and the part it played in World War II, the text and good diagrams and photographs should help appreciably to stir up public interest. On the silviculture and conservation of forest the book is not so strong. The still inadequate action in many countries is not recognized However, the author, who is himself in the timber trade, advocates strongly the better education of that trade and of timber users, more research into the growing and using of trees, and international exchange of information on forests and forest-products. With those views few will disagree.

On the political views expressed in Chapter IV, somewhat surprisingly in a book of this kind, there is bound to be diversity of opinion.

Ships of the Redwood Coast. By Jack McNairn and Jerry MacMullen. Stanford University Press, California. $3. (Geoffrey Cumberlege, Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 18*s.* 6*d.*)

THE home of *Sequoia sempervirens* Endl. is in the north-west of California, in a coastal area about 400 miles long by 30 miles wide. This book, true to its title, is mainly about the ships and men of the redwood lumber trade. There is little about the tree or the redwood forests themselves, though there are some photographs and interesting scraps of information. On the ships and men the book is full of interesting details. It gives a vivid account of the difficulties under which the small schooners of 'California's Scandinavian Navy' worked redwood lumber from the 'dog-holes' (coves and bays) of a dangerous coast, mooring under 75-foot cliffs whilst the lumber was loaded down slides or chutes

from the cliff-tops to their decks. The photographs and records of wrecks and successful voyages are proof of the dangers described and the courage and skill displayed. The zenith of the trade was in 1906, owing to the San Francisco earthquake and fire, and the urgent need of lumber. Kipling would have found a rich mine in this book for a companion to his *Captains Courageous* of the other ocean.

Fire Control Notes, Vol. 7, No. 1. Forest Service, U.S. Department of Agriculture, Washington, 1946.

AFTER a war-time suspension of four years this lively and original publication of the Division of Fire Control of the U.S.A. Forest Service is again in publication and promises to appear quarterly.

The intention of the Forest Service is that 'this publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control'. Few foresters in this country will disagree that we have a great deal to learn about all branches of fire protection, and we can learn a great deal from America. Of course, our conditions and theirs vary, but not the basic principles, and while plans are being made for the creation of extensive plantations, plans should also be made for their adequate protection.

In an interesting collection of articles those dealing with adapting army equipment, and especially jeeps, to forest fire fighting, and the use of helicopters for fire control are particularly instructive, but there is a wealth of bright ideas and gadgets, and future issues of this enterprising periodical should be studied if we are to be forearmed.

Longleaf Pine (*Its Use, Ecology, Regeneration, Protection, Growth, and Management*). By W. G. Wahlenberg, Forester, Southern Forest Experiment Station, Forest Service. Published by the Charles Lathrop Pack Forestry Foundation, Washington, D.C., in co-operation with the Forest Service, U.S. Dept. of Agriculture. January 1946. Price $5.

THIS is an invaluable comprehensive monograph on *Pinus palustris* Mill. It is well illustrated and documented, the bibliography listing over 600 articles and books. The author has put 20 years of practical experience of southern pines into the book, and drawn widely on the knowledge of other experts. His enthusiasm for the famous timber tree on which he is writing is admirable.

He records that the present stand of longleaf pine is perhaps a third to a half of the original stand when lumbering began, and the volume of saw-timber only about one-tenth of what it was. Nevertheless, 'if the many pitfalls that threaten longleaf reproduction can be avoided, the culture of this unusually resistant and fire-hardy tree is relatively easy. Forestry enterprises that possess longleaf pine growing stock can ill afford to disregard the species—one of the finest timber trees the world has known'.

It is hoped to review the book in the next number of *Forestry*. There is particularly interesting information on the effect of rate and conditions of growth on the quality of the timber produced.

Report of the Commissioner The Hon. Gordon McG. Sloan, *Chief Justice of British Columbia, relating to the Forest Resources of British Columbia, 1945*. Victoria, B.C., 1945.

THE report is of outstanding interest and importance, dealing clearly and thoroughly with one of the major softwood forest areas of the world. The findings and recommendations appear sound and well balanced. Action is obviously urgent, but silvicultural

conditions (and accessibility in the coastal forests) are so exceptionally favourable that the position is relatively easy. If the necessary action is taken the present lumber output can be maintained or increased, and the immensely valuable forest estate can be brought under sustained yield management. (There are many forest areas in other parts of the world where the problem is much harder.)

Fire protection, especially of crops up to 20 years of age, is regarded as vital. One highly qualified witness is quoted as saying that 'fire-protection is 80 per cent of reforestation'.

At the present rate of cutting the mature Douglas fir in the coastal forests may be cut out in about 30 years, but there will still be ample hemlock in the same forests, great volumes of Douglas fir in the interior forests, east of the Coast Range, and second-growth forests should be increasing fast.

The report recommends control of the forests and of a greatly increased expenditure on forestry by a Forest Commission of three to five members. 'Their duties are bound to compel them from time to time to make far-reaching decisions concerning matters in which private and public interests will be in conflict. They must therefore be in a position to reach their conclusions free from any self-interest and solely on the basis of merit.'

The report appears to have been welcomed by the lumber industry and by the foresters of British Columbia. To the government of that province the delegation of control recommended may seem hard to stomach, but in the light of past history, recorded in the report, and the urgency of a prosperous future for these superb forests, it is greatly to be hoped that the recommendations will be adopted.

Forests for the Future: Conditions essential to a sustained-yield policy for management of British Columbia Coast Forests. By H. R. MacMillan. Published by the H. R. MacMillan Export Company, Ltd., Vancouver, 1945.

THIS statement of opinion by a leader of the lumber industry in British Columbia is based on the brief he submitted to the Royal Commission whose report is noticed above. It is instructive to read the two together. It is significant also and encouraging that this brief from the lumber industry should be so ably presented, with full acknowledgement of the essentials of sound forestry, such as the sustained yield, good silviculture and utilization, and research.

There is plain-spoken criticism at page 46 and elsewhere of the Provincial Forest Branch and of the Forest School of the University of British Columbia. Presumably there are two sides to the case. Without attempting to judge it one may welcome the attention being paid to forestry in general and forest research and education in particular in an area where it is specially important.

Observations on the growth of the next forest crop in the Lower Fraser Valley and Southern Vancouver Island. By John D. Gilmour, B.Sc.,F. Forester for H. R. MacMillan Export Co., Ltd., 1945.

THIS booklet also should be read in conjunction with the one noticed above and the report of the Royal Commission on the forests of British Columbia. The main facts brought out are the extremely favourable conditions for rapid tree growth in the coastal forests, the heavy stands of second-growth springing up where fire does not interfere, and the tendency for hemlock (*Tsuga*) to replace Douglas fir (*Pseudotsuga*) in the new crops. At page 17 there is a summary of the major differences between hemlock and Douglas fir. Douglas fir is a somewhat stronger wood and more durable when exposed to weather. Hemlock is a moister wood when green, so it requires more seasoning, and it is useful for

all kinds of wood-pulp, whereas Douglas fir has not yet been found equally good for pulping.

'Their forest characteristics are also different. Fir is more light-demanding; Hemlock will do well under shade conditions. Fir bears irregular seed-crops, its seeds are sought as food by rodents and birds, they demand certain seed-bed conditions, and they do not travel far by wind. Hemlock produces plentiful seed crops almost every year, its seeds seem to be inedible to most animals, they travel farther by wind, and grow readily under varied seed-bed conditions.

'For these reasons Hemlock in this region is crowding out the Fir over a large proportion of cut-over and burned-over land. Hemlock may constitute as much as 75 per cent. of the next crop on land which previously carried a predominantly Douglas Fir forest.

'. . . The growth of Hemlock per acre per year is approximately 40 per cent. higher than that of Fir on similar sites.'

An Article in 'The Economist' of 21 September 1946, at page 464, entitled 'American Survey. Douglas Fir'. By a Correspondent in Oregon.

(The above notices on Douglas fir in Canada link up with a well-balanced appreciation of the situation in the Douglas fir zone of the U.S.A. It is reproduced below by courtesy of *The Economist*, with grateful acknowledgements to that journal and the author.)

' "Timber!", the lumberjack's warning that he is bringing a forest giant crashing to earth is gradually being muted by governmental direction in the douglas fir country, and the old time sawmill men do not like it. The douglas fir region (the western portions of the states of Oregon and Washington) supplies one-third of all the timber cut in the United States. Fifty-five per cent of the remaining timber stands in the region are in national forests. More and more, therefore, sawmills will have to turn to the Forest Service of the federal government for logs. They will have to cut how, when and where the Forest Service tells them to. Most of them find the prospect disquieting.

'The presence of a few great lumber barons has obscured the fact that the lumber industry is made up of thousands of separate units. The 461 million acres of forest land in the United States are owned by 4,200,000 individuals and firms. There are thousands of sawmills. Most timber owners have no mill. Hundreds of mills own no timber. Hundreds of loggers own neither mill nor timber.

'In the douglas fir region, the average land holdings are much larger than the national average, but even here there are hundreds of mills and independent loggers. Scores, perhaps hundreds, of these operators will not be able to survive on logs from the public domain, because public domain timber is less accessible and of inferior quality. The best and most accessible stands had passed into private hands before the Forest Service was organized, four decades ago. Moreover, the Forest Service will not sell logs fast enough to keep all present mills going. The rugged individualists in the lumber industry are not meekly accepting this situation. They have been arguing with the Service for years. But until now their arguments have lacked spirit, for the industry has been cutting its own trees on its own lands in its own wasteful but profitable manner. But now they can see the end of that era, and the debate becomes vital.

'A forest analyst employed by the industry reported recently that the douglas fir belt could, with ideal but still practicable logging and timber management, sustain an annual cut of 13 billion board feet and pulp wood forever. This estimate was set against the actual cut, which even under the pressure of the war-time demand did not reach 10 billion feet annually. Here, it would seem, was the answer to the assertions of the Forest Service that these timber resources were being too rapidly consumed. Much of the data for the

estimate were in fact obtained from the Forest Service. Such an estimate, however, like the much lower estimates of the Forest Service, is a debatable conclusion based on amazingly complex and variable factors covering of necessity a period of 50 to 100 years. The estimate is a calculation used to support an argument, not a basic fact.

'The argument put up by the industry is that the Forest Service could, nay must, permit more and faster logging in the public timber. Most of the virgin fir is said to be over-ripe, meaning that annual loss through decay, insects, disease and windfall equals or exceeds annual growth, while new growth on cut-over lands runs from, say, 500 to 2,000 million board feet per year. Consequently the over-ripe areas should be logged quickly to prevent loss and to get vigorous new growth started. The forest analyst already referred to estimated that if this were done annual growth in the fir belt would equal 20 billion feet annually, more than twice the largest annual cut.

'The Forest Service answer is that if unhindered logging were permitted, there would come a time when all the merchantable trees would have been cut, and there would be a gap of many years with no logs while new growth was reaching merchantable size. (It takes from 50 to 100 years for a fir tree to reach merchantable size.) So, some old trees must be kept until new ones are ready to cut, even at the cost of a slight depreciation. Sustained yield is best for all. And in laying out a sustained yield programme the Forest Service takes into consideration factors which the lumber industry has ignored. From the beginning, the Service policy has been to utilize the forests for the good of all the people. The forests are a quadruple public asset; recreation, hunting, fishing and camping; grazing for sheep and cattle; watersheds; and logs. The only value which the lumber industry has utilized on its own lands has been the logs; its practice has been compared to mining to cut out everything profitably usable, then move on to a new tract, letting the denuded land slip back to public ownership through tax delinquency. But vigorous young forests that are now growing on many thousands of these acres is due to mere chance, in too many instances. Hundreds of square miles of clear-cut acres, too mountainous for farming, have eroded and gone to bracken, forever useless unless replanted by hand, a costly task.

'The Forest Service is determined to prevent this happening on the public domain. To prevent it, logging is done selectively, that is, only the ripe declining trees are taken out in the first cut; or, where this is not feasible, clear-cut logging is done in strips, leaving ample stands to check erosion, to catch water and to provide seeds for natural re-stocking.

'Watersheds must be protected. The forests, with their deep layer of needles and mould, are, in fact, great sponges which absorb heavy rains and melting snow, regulating and sustaining the flow in streams which support great irrigation and power projects and supply water for municipalities. Silt from denuded hills could quickly fill the reservoirs behind great dams, and this has actually happened in places where logging was uncontrolled. So, before opening an area to logging, the Forest Service must do extensive intricate planning to ensure the protection of recreational and water values and to provide a regular crop of logs for ever. This done, the Service invites the industry, from time to time, to bid on logging rights in certain limited areas. The Service expects the industry to make a profit, and its advertised prices for stumpage are set accordingly. Loggers usually bid more than the advertised price.

'The industry might have no quarrel with this procedure if the offerings were larger. But usually they are too small to satisfy the requirements of large existing mills. The forests support, in one way or another, half of all the people in the fir belt. Mills are shutting down now as they use the last of their private log supply. The pressure on the Forest Service to relax is expected to increase. However, over 90 per cent. of the logs cut in the fir belt are still being cut on private lands, and the Service hopes that a gradual

reduction in mills and a general appreciation of the issues will bring public support before disaster.

'There are encouraging signs. Relations between the Forest Service and the industry, up to now, have not been hostile, and in many cases have been co-operative. Funds have been made available for joint efforts in fire protection, in pest control, in building roads, in research. Some of the big private operators with vast holdings are setting up sustained yield programmes on their own lands—one corporation has half a million acres in young trees which it is tending against the time when its virgin stands will be cut. The business of nursing along young stands has reached a point where "tree farms" and sustained yield operations are attracting the interest of conservative investment capital—insurance companies are said to be making inquiries. But in the overall picture these tree farms are, as yet, mere kindling wood. While they assure future operations for their owners, they are not yet extensive enough to influence the lumber industry as a whole.

'Recently a privately held stand, too small for feasible sustained yield operation (as are most holdings), has been combined with a national forest stand, to make a practical sustained yield unit. In entering this arrangement, the private owner agreed to log his land in a manner worked out co-operatively with the Forest Service. In return he is assured that the logs in the national forest will be sold to him at an appraised price. In other places, arrangements have been made by which the Forest Service exchanges standing timber for a larger acreage of cutover land which will eventually produce another crop. In this deal the private owner agrees to log to Forest Service standards. So for the nation and its lumber supply the situation is not hopeless. But for many individuals in the lumber industry, over-expanded as it is, the future is going to be difficult.'

Extracts from *Forestry Abstracts*

THE following abstracts are reproduced by permission of the Imperial Forestry Bureau, Oxford, from their quarterly journal. They relate to the more important recent books of special interest to British foresters, not reviewed or noticed elsewhere in *Forestry*.

The Bureau aims at impartial abstracting, not at critical reviews, and covers the forestry literature of the world. Since 1938 seven volumes of *Forestry Abstracts* have been published. The seventh volume is almost double the size of the first. To provide for the many who are interested in either production of wood or its utilization, but not in the details of both these fields, from Vol. 8, No. 1, of September 1946, *Forestry Abstracts* is available either as a whole or as a separate impression of Section 3 only, under the subtitle *Forest Products and Utilization*. The annual subscription for British residents is 20*s*. for the whole or 10*s*. for the *Forest Products and Utilization* part only, including postage, payable to Imperial Agricultural Bureaux, Central Sales Branch, Agricultural Research Building, Penglais, Aberystwyth, Wales.

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12.11.3. *Heredity. Breeding. Races and Questions of Provenance. Cytology.*

12.11.3. Richens, R. H. *Forest Tree Breeding and Genetics.* Joint Publ. Imp. Agric. Bur. No. 8, 1945. pp. [v]+79. [E.e.g.f.span.] [1597.]

During the last ten or fifteen years considerable progress has been made in genetical studies with forest trees, with a view to improving the existing stock through selection, breeding and related techniques. At present there is no publication bringing together all the information which already exists in this important field, and it is becoming increasingly difficult for research workers to keep abreast of all modern developments. In addition,

many of the more important papers have appeared in comparatively inaccessible German, Russian and Swedish forestry journals, and have not been readily available to those interested in forest tree breeding in the Empire.

This bulletin collates the more important papers on this subject that have appeared since 1930. General principles of tree breeding are described in an introductory section with a brief account of the basic theoretical concepts. The methods so far used include line breeding, the development of hybrids exhibiting heterosis, and the utilization of polyploids.

The selection criteria that have been used by tree breeders include timber yield, photoperiodic adaptation, high reproductive capacity, tree shape, wood quality, competitive ability, and resistance to bacteria, fungi, insects, viruses, low temperature and other unfavourable environmental conditions. These characters are considered in general and with special reference to the tree genera treated in the bulletin, viz. *Abies*, *Cupressus*, *Juniperus*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, *Sequoia*, *Tsuga*, *Acer*, *Aesculus*, *Alnus*, *Betulus*, *Buxus*, *Carpinus*, *Carya*, *Castanea*, *Eucalyptus*, *Fagus*, *Fraxinus*, *Ilex*, *Juglans*, *Platanus*, *Populus*, *Pterocarya*, *Quercus*, *Robinia*, *Salix*, *Tectona*, *Tilia and Ulmus*.

A glossary of the technical terms used in the bulletin and a bibliography of 605 references are appended.

31 : 31.4 : 33.36. Henderson, F. Y. *Timber: its Properties, Pests and Preservation.* Crosby Lockwood and Son, Ltd., 20 Tudor Street, London, E.C.4. 2nd ed., 1944. pp. 148. Price 10*s.* 6*d.* [1792.]

Since 1939, when the first edition of this book was published [cf. *For. Abstr.* 1 (309)], there has been a great expansion in the use of timber and its products, particularly of plywood and its derivatives, and the text has been expanded accordingly where necessary. Chapters deal respectively with the following subjects: the tree; the structure of softwood, and of hardwood; how a log is cut up; texture, grain and figure; colour and odour; hardness and density; water in wood; the strength of timber; natural defects; durability and decay; destruction by animals; seasoning; preservation; notes on common timbers; timber identification; timber bending; veneers and plywood; the examination of woods for the presence of fungi. There are 61 illustrations, an index and a short bibliography.

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12.11.3 (47.0). Hudson, P. S., and Richens, R. H. *The New Genetics in the Soviet Union.* Imperial Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge. 1946. pp. 88. [E.e.f.span.g.russ.] Price 6*s.* net. [902.]

The so-called genetics controversy in the U.S.S.R. has excited interest in the rest of the world during the last ten years or more. However, many of the views expressed regarding the merits of the Soviet schools of thought based on Mičurin and Lysenko have been inaccurate; the inaccuracy has resulted firstly from the fact that the originals were all published in Russian and biologists in other countries have been unable to consult them; and secondly, from the emotional approach which seems to be so difficult to overcome in dealing with problems affecting the Soviet Union.

12.25–8 (410). Brimble, L. J. F. *Trees in Britain, Wild, Ornamental and Economic, with some Relatives in other Lands.* Macmillan and Co., Limited, St. Martin's Street, London. 1946. pp. x+352+plates. Price 15*s.* [946.]

This book on trees deals with a high proportion of the indigenous and exotic species in Britain, arranging the information in botanical sequence by families or generic groups and

allotting to each species a varying amount of detail on diagnostic features, aesthetic appearance, conditions of growth in woodland and in garden, economic uses and role in literature or folklore. The factual data are instructive, well selected and readably compressed. Space is found for numerous quotations from poems, verse, rhymes and the Bible. The introductory section provides a general review of flowering plants, accounts of the structure of broadleaved and coniferous trees and the principles of classification. A successful feature is the variety of methods of reproduction of the illustrations which include line drawings, pencil and water-colour sketches and photographs ranging from the diagrammatic to the artistic.

23.2 (44). POURTET, J. *Les repeuplements artificiels.* [*Artificial Regeneration.*] École nationale des Eaux et Forêts, 14 Rue Girardet, Nancy. 1946. pp. 184+charts. [F.] [1032.]

A practical manual designed for the use of officers of the Forest administration and private landowners interested in reforestation. The methods recommended are simple, and are the result of field experiments by the author. The book contains sections on the following subjects: seeds, direct sowing, plantations, silvicultural methods for the principal species used in reforestation, introduction of species into existing forests, methods of reforesting various soil types, planting canal banks, shelterbelts, etc.

23.2 (79.5: 79.7). KUMMEL, J. F., RINDT, C. A., and MUNGER, T. T. *Forest Planting in the Douglas-fir Region.* U.S. Forest Service, Portland, Oregon. 1944. pp. iv+154+plates. [1033.]

This bulletin describes the various techniques of nursery practice and artificial reforestation that have been found practicable in the Douglas Fir region of western Washington and Oregon. It is intended for the use of seed collectors, nurserymen, planting foremen and foresters who are engaged in the management of forest lands. It deals primarily with Douglas Fir but makes some mention of the associated species of the area covered.

31.0 (410): 21: 31.2: 33.36.3. BOULTON, E. H. B., and JAY, B. A. *British Timbers: their Properties, Uses and Identification, with Notes on the Growth and Cultivation of Trees.* Adam and Charles Black, 4, 5 and 6 Soho Square, London, W.1. 2nd ed., 1946. pp. 120+plates. Price 12*s.* 6*d.* [Timber Development Assoc ion.] [1083.]

[Cf. *For. Abstr.* 6 (93) for an extensive review.] In the second edition of this book, the authors increase its usefulness by the inclusion of tables of strength figures and kiln schedules for the more important British timbers, and of notes on their fuel value.

97.1. JACKS, G. V. *Land Classification for Land-use planning. Tech. Commun. imp. Bur. Soil Sci.* No. 43, 1946. pp. 90. Price 4*s.* net. [1553.]

Land classification must form the basis for the planned utilization of land. Interest in land-use planning as a means of avoiding the economic disasters that overwhelmed agriculture before the war and the land deterioration that resulted from faulty land use, and, on the international scale, of securing a better balance between the supply of and demand for agricultural products has become world-wide. Yet the science of land classification is still in its infancy. It is essential that everybody engaged in land-use planning, whether in the field or in the office, should know the basic principles of land classification so far as they have been developed, what the classifier aims to do, what factors—geographical, social and economic—are involved, and what are the limitations of land classification.

These matters are discussed in this Technical Communication, which is a summary of

the published literature on land classification so far as it concerns the planning or agricultural and forest land. In addition to a review of general principles, numerous examples are given of actual systems of land classification, and a section is devoted to the several schemes for quantitatively expressing soil productivity, known as 'productivity ratings' in America and *Bodenbonitierung* in Germany.

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The index has been prepared by Professor T. Thomson, late of University College of North Wales, Bangor, and the Society desires to express its thanks to him for undertaking this work.